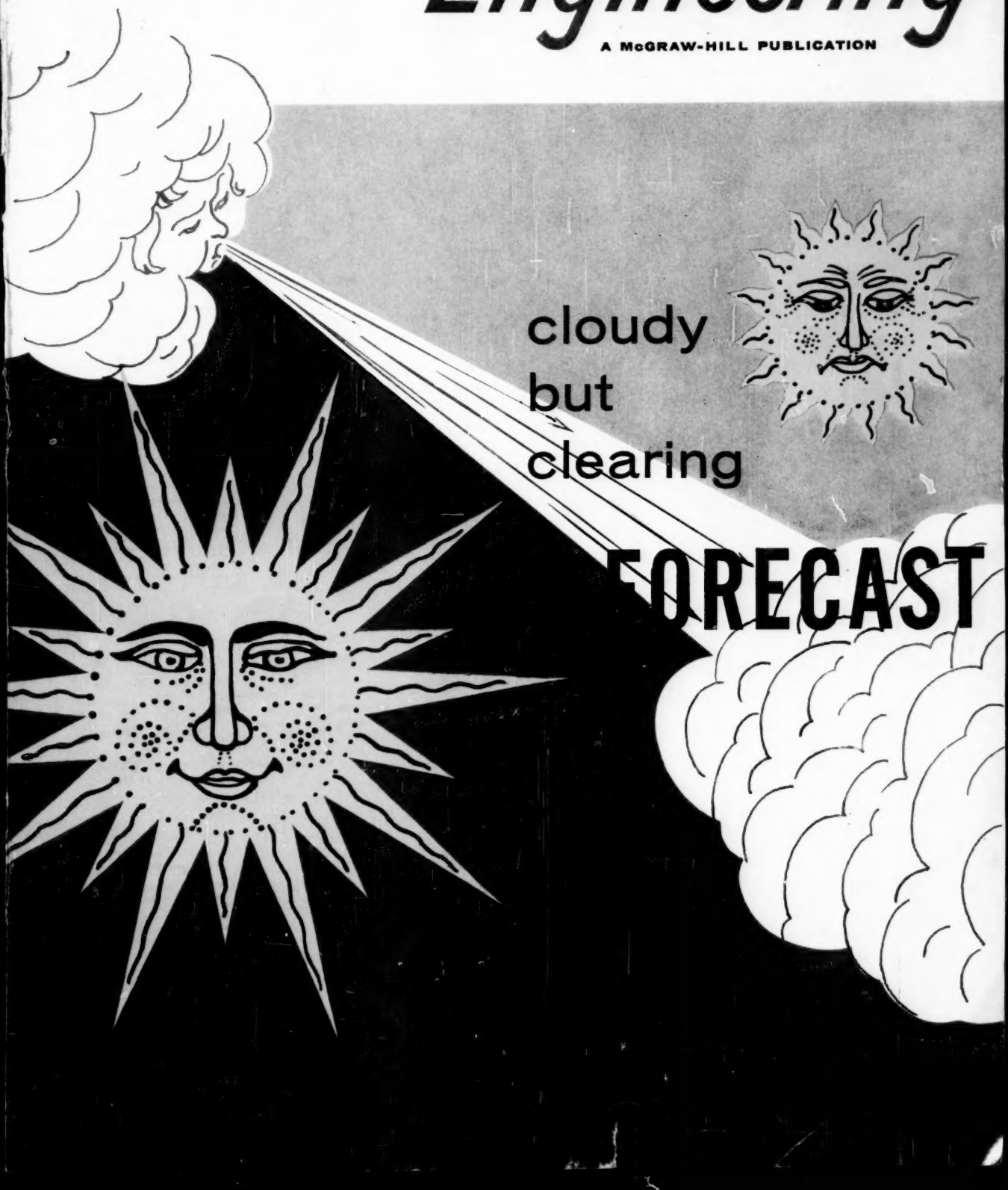
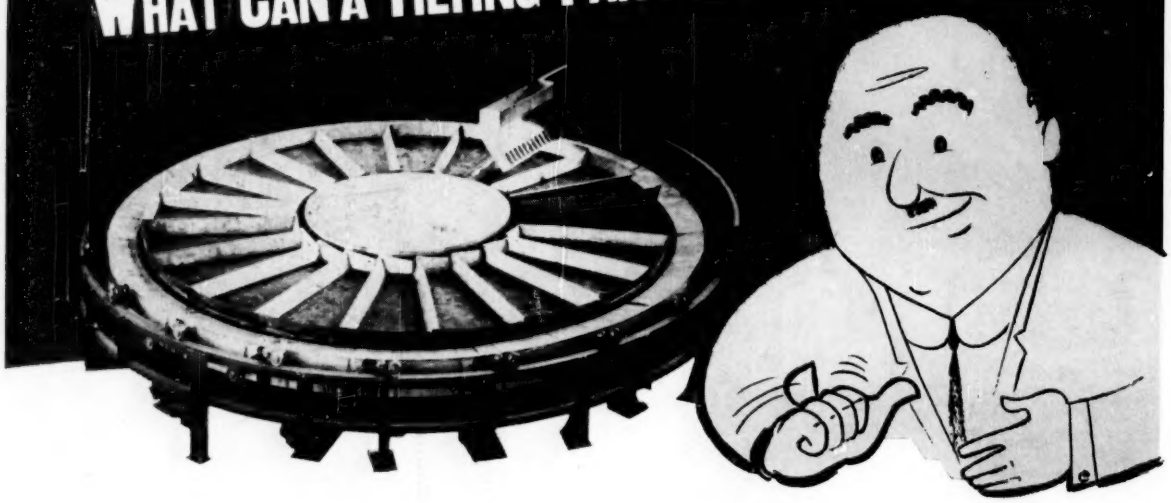
JANUARY 9, 1961
Published every-other-Monday
Seventy-five cents

Chemical Engineering

A McGRAW-HILL PUBLICATION



"WHAT CAN A TILTING PAN FILTER DO FOR ME?"



It Can Handle Materials That Are Too Free-Filtering for Vacuum Pick-Up

Effective filtration of a broad category of rapid settling and dewatering slurries that require intensive washing can be accomplished only on horizontal pan filters especially designed for this feed.

Eimco's leadership in engineering a succession of advanced design features into this specialized filter has so improved its performance that the usefulness of the unit has been greatly extended. Modern Eimco Tilting Pan filters have been applied for continuous processing of such materials as phosphoric acid, beryllium, iron ore fines.

It Can Give You Better Washing Efficiency Than Any Other Filter . . .

Eimco Tilting Pan filters provide close control of washing, dewatering, drying, air sweep. One, two, three or more displacement wash separations can be made every filter cycle. Amounts of wash water and cake on each pan can be balanced precisely. Uniformity of wash water distribution can be controlled.

Cloth media on each pan is spray cleaned after cake discharge. A new and exclusive Eimco vacuum purge then removes any cleaning water left in the lower corner of each pan.

NEW Bulletin

EIMCO TILTING PAN FILTERS

Contains valuable information on the use and economics of this special filter. Ask the Eimco Representative in your area for your copy or write Eimco Filter Division for

BULLETIN F-2038A

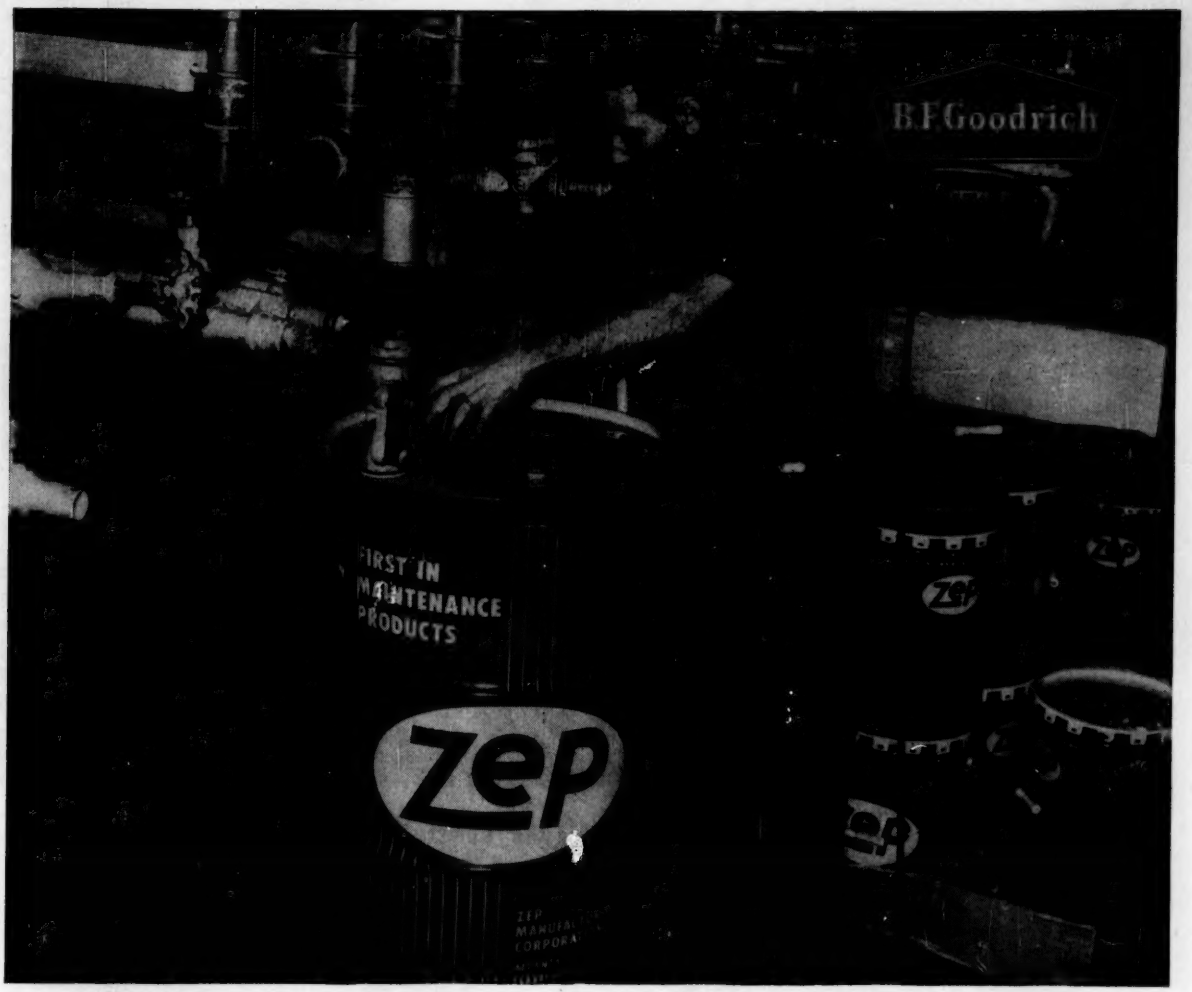
THE EIMCO CORPORATION

EIMCO

FILTER DIVISION
634 SOUTH 4TH WEST
SALT LAKE CITY, UTAH — U.S.A.

RESEARCH AND DEVELOPMENT CENTER
301 SO. HICKS ROAD, PALATINE, ILLINOIS

B - 598



Koroseal keeps contamination out of cleaning compounds

Koroseal PVC pipe, by B.F.Goodrich, ends corrosion too

EVEN stainless steel can't handle some of the chemicals used in this plant. Corrodes too fast! But the real problem is that metal pipe would contaminate some of the commercial cleaning compounds produced here. That's why Koroseal PVC pipe was installed on all lines where corrosion or contamination could cause trouble.

Koroseal won't corrode. It's unaffected by most acids, alkalies, salt, alcohol and oil. Solutions carried remain pure. Koroseal pipe does not react chemically, will not contaminate products.

Koroseal was first tried out by the Zep Manufacturing Corp., Atlanta, Ga., about 10 years ago. Since then, they've found many more uses for it, and have never had to make a replacement because of chemical corrosion. Installation is simple. Koroseal pipe can be threaded, welded, cemented. And according to Zep's engineers," component fittings, valves and pipe fit together like the parts of a fine watch."

More and more manufacturers are finding Koroseal PVC pipe ideal for use wherever chemical resistance, high working pressures, good impact resistance are factors. Longer service life and low installation costs make rigid Koroseal competitive with conventional piping material.

For the full story on Koroseal's many advantages, get in touch with a B.F.Goodrich distributor or write for a free booklet. *B.F.Goodrich Industrial Products Co., Department M-949. Akron 18, Ohio.*

Koroseal—T.M. Reg. U.S. Pat. Off.

B.F.Goodrich Koroseal rigid PVC products

DELIVER YOUR SOLID-LIQUID SEPARATION PROBLEM TO

and You come out with the right answer

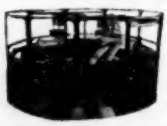
Here are 8 good reasons why:

THE BIRD CONTINUOUS SOLID BOWL CENTRIFUGAL counts its varieties of successful applications in the hundreds. It comes in over a hundred different size and design variations.

THE NEW BIRD "COMPACT" CENTRIFUGAL with 6-inch bowl, running at speeds up to 6000 RPM, opens up new and valuable opportunities for both production and pilot plant operations.

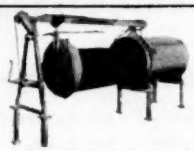
THE BIRD CONTINUOUS SCREEN TYPE CENTRIFUGAL deliquors and washes crystals or granules from heavy feed slurries; effective wash with less than 0.1 lb. wash liquor per lb. of solids.

THE BIRD-YOUNG ROTARY DRUM VACUUM FILTER features high throughput from small filter area and minimum floor space; efficient wash; ideal for economical fume-tight operation.



THE BIRD-PRAYON TILTING PAN ROTARY VACUUM FILTER provides constant high tonnage output of thoroughly washed solids with complete separation of mother liquor and wash liquors. Filter area ranges from 27 to 516 sq. ft.

THE BIRD-HUMBOLDT OSCILLATING SCREEN CENTRIFUGE dewaters plus 65 mesh solids with almost no degradation or loss of solids. Output up to 80 tons or more per hour. Extraordinarily low cost of operation and maintenance.



THE BIRD PRESSURE LEAF FILTER offers large filter area, high rate of flow, working pressures up to 75 psi or more, in a wide range of sizes and corrosion resistant constructions.

THE BIRD SUSPENDED BATCH CENTRIFUGE is built for heavy duty service, with 26″, 40″ or 48″ basket, perforate or imperforate. Custom built and accessoried; fume-tight or explosion proof if desired.

Eight Reasons Why The Recommendations Based On Tests At The Bird Research and Development Center Will Be Unbiased And May Be Depended Upon.

BIRD MACHINE COMPANY

SOUTH WALPOLE, MASSACHUSETTS

BUILDERS OF THE COMPLETE LINE OF SOLID-LIQUID SEPARATING EQUIPMENT

Operators of the **Bird Research and Development Center** for pilot-scale testing to determine the correct equipment for the job. Yours to use.

Application Engineering Offices:

EVANSTON, ILL. • ATLANTA, GA. • HUNTINGTON, W. VA. • LAPORTE, TEXAS • WALNUT CREEK, CALIF.

Chemical Engineering

January 9, 1961

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

PRINT ORDER FOR THIS ISSUE 53, 298

WHAT'S HAPPENING

33 CHEMENTATOR *R. A. Labine*

42 INDUSTRY & ECONOMIC NEWS *A. V. Gemmill*

Jungle Oil Refinery—Made in U.S.A. 42

Decade to Double Aluminum Use 46

Chemical Spending: Still Growing *A. Litwak* 48

Huels Perchloroethylene Process 52

58 NEW CHEMICALS *E. Guccione*

64 NEW EQUIPMENT *F. C. Price*

You Picked These as Most Interesting Equipment Cost Index 159

74 PROCESS FLOWSHEET *N. P. Chopey*

How to Make Azo Pigments

ENGINEERING PRACTICE

83 FEATURE REPORT

Cloudy but Clearing: CPI Forecast for '61

95 FEATURE ARTICLES

Numerical Solution of the Heat Conduction Equation *Y. L. Luke* 95

Mathematics of Control *T. J. Williams* 103

Powerful Tool: Statistical Mechanics *J. S. Dahler* 111

120 YOU AND YOUR JOB *W. C. Schall*

Does Your Pay Measure Up? *A. W. Gray*

FREE—For your files, an extra copy of this article. Check Reader Service Postcard, p. 169

124 OPERATION & MAINTENANCE *P. J. Brennan*

Manufacturing: Art or Science? *W. H. Richardson* 124

130 CORROSION FORUM *R. B. Norden*

Spray "Trowelable" Coat on Concrete 130

OTHER REGULAR FEATURES

146 CONVENTION CALENDAR

160 TECHNICAL BOOKSHELF

165 LETTERS: PRO & CON

169 READER SERVICE POSTCARD

171 REPRINTS NOW AVAILABLE

172 MANUFACTURERS' LITERATURE

190 CLASSIFIED ADVERTISERS

198 INDEX OF ADVERTISERS

199 ADVERTISING REPRESENTATIVES

VOLUME 68, NUMBER 1

Chemical Engineering (with Chemical & Metallurgical Engineering) is published biweekly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder.

Publication Office: 99-129 North Broadway, Albany 1, N. Y.

Executive, Editorial, Circulation and Advertising Offices, 330 West 42nd St., New York 36, N. Y. **Officers of the Publications Division: Nelson L. Bond,** President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator. **Officers of the Corporation:** Donald C. McGraw, President; Joseph A. Gerardi, Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary.

Subscriptions are solicited from engineers and other technical men in the Chemical Process Industries. **Position, company connection, and nature of company's business, products, and approximate number of employees, must be indicated on subscription application.** Subscription rates per year for individuals in the field of the publication: U. S. and Possessions $3 (single copies 75¢). Canada $4, other Western Hemisphere $15, all others $25. The publisher, upon written request from any subscriber, agrees to refund the part of the subscription price applying to copies not yet mailed.

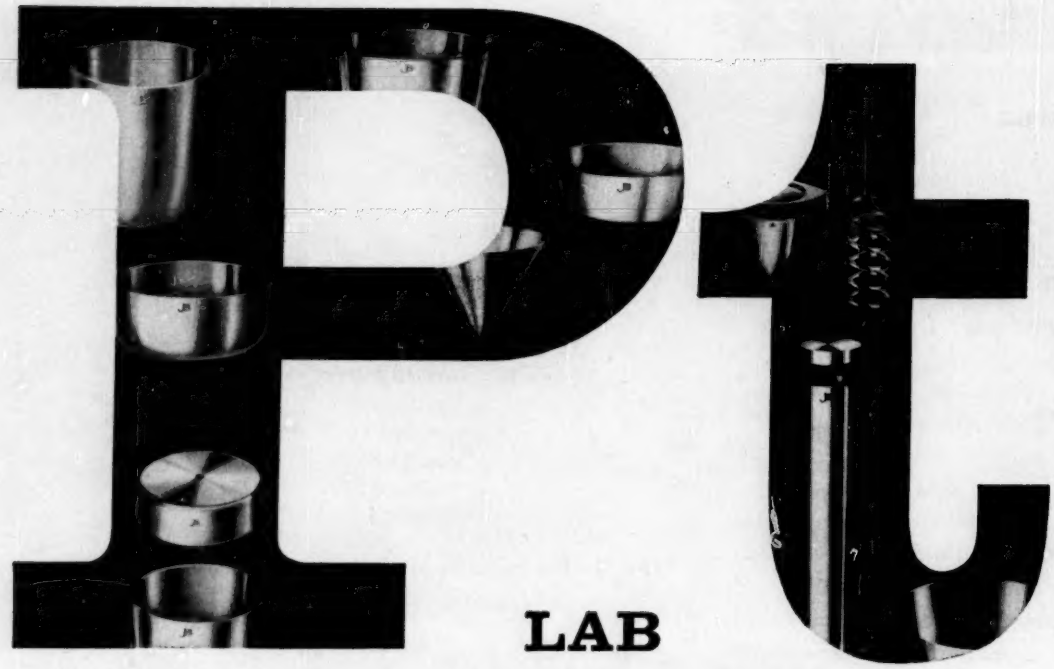
Second class postage paid at Albany, N. Y. Printed in U.S.A. Title registered in U.S. Patent Office.

©Copyrighted 1961 by McGraw-Hill Publishing Co., Inc. All rights reserved. Member A.B.P., A.B.C.

Subscriptions: Send correspondence and change of address to Fulfillment Manager, Chemical Engineering, 330 West 42nd Street, New York 36, N. Y. Send notice promptly for change of address, giving old as well as new address. Enclose an address label from a recent issue of the magazine if possible. Allow one month for change to become effective.

Postmaster: Please send form 3579 to Chemical Engineering, 330 W. 42nd St., New York 36, N. Y.

Audit Bureau of Circulations — Associated Business Publications



LAB APPARATUS

a complete line of quality ware . . . crucibles, dishes, electrodes, gauze, sheet, strip, foil, wire and tubing . . . don't forget your used lab ware has high scrap value.

Write for our NEW catalog

BISHOP

J.BISHOP & CO. *platinum works* / 95 KING STREET, MALVERN, PENNSYLVANIA

A JOHNSON MATTHEY ASSOCIATE PHONE: NIAGARA 4-3100

Chemical Engineering
JANUARY 9, 1961

PUBLISHER

J. Elton Tuohig

EDITOR-IN-CHIEF

Cecil H. Chilton

WHAT'S HAPPENING

EDITOR: Calvin S. Cronan

ASSOCIATE EDITORS: Frances Arne, A. V. Gemmill

ASSISTANT EDITORS: Nicholas P. Chopey, Eugene Guccione, Roland A. Labine, Frederick C. Price

ENGINEERING PRACTICE

EDITOR: Theodore R. Olive

ASSOCIATE EDITORS: Steven Danatos, Robert B. Norden, William C. Schall

ASSISTANT EDITORS: Peter J. Brennan, Roy V. Hughson, James R. Marshall

PRESENTATION & PRODUCTION

EDITOR: Lester B. Pope

SENIOR ART EDITOR: Frank F. Kozelek, Jr.

ASSOCIATE ART EDITOR: Louis H. Dufault

ASSISTANT ART EDITOR: D. Caratzas

COPY EDITOR: Henry S. Gordon

EDITORIAL ASSISTANTS: Joan Nilsen, Nancy Pepicello

REGIONAL EDITORS & BUREAUS

HOUSTON: Thomas H. Arnold, Wilma Cortines

SAN FRANCISCO: Martin D. Robbins, Terry Shaw

DOMESTIC NEWS BUREAUS: Atlanta, Chicago, Cleveland, Dallas, Detroit, Los Angeles, San Francisco, Seattle, Washington

WORLD NEWS BUREAUS: Beirut, Bonn, Caracas, London, Mexico City, Moscow, Paris, Rio de Janeiro, Tokyo. Correspondents in 153 cities in 61 countries.

CIRCULATION

MANAGER: Paul W. Erb

ADVERTISING & BUSINESS

ADVERTISING SALES MANAGER: D. B. Gridley

BUSINESS MANAGER: Anton J. Mangold

PROMOTION MANAGER: Hugh T. Sharp

MARKET RESEARCH MANAGER: Jeanette Paschall

ADVERTISING MAKEUP: Grace Barrie

highlights of this issue

CLOUDY BUT CLEARING: CPI FORECAST FOR '61

Does talk about the "profit squeeze" in the CPI conjure up visions of a depressed industry? Don't be alarmed; there's an interesting, exciting—even profitable—future ahead for all of us. Our annual review and forecast (p. 83) covers current developments in petrochemicals, fuels, fibers, plastics, metals, fertilizers, industrial gases and other major chemicals, with predictions of things to come.

IS YOUR "TRADE SECRET" REALLY A TRADE SECRET?

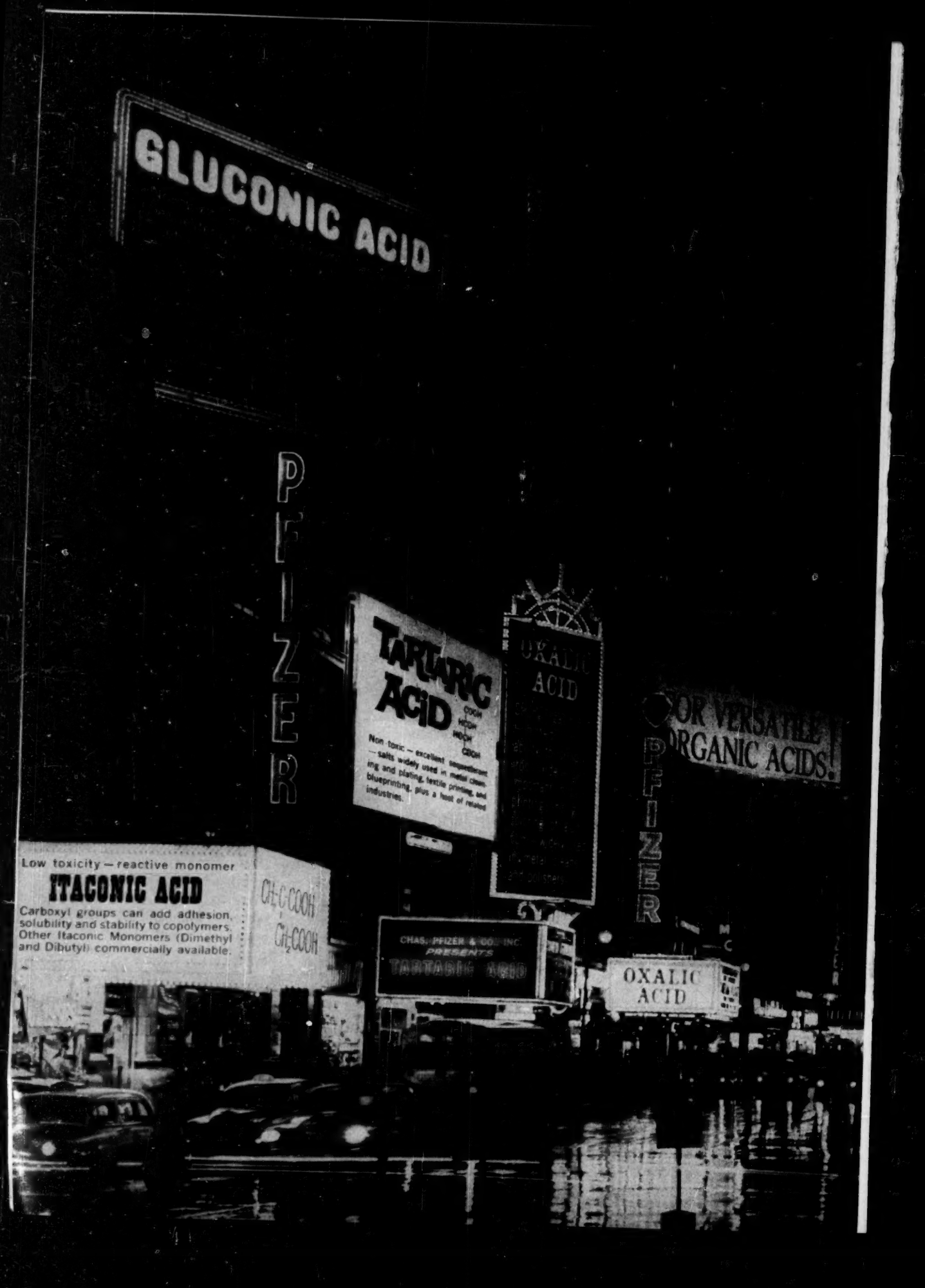
Your conscience may not necessarily be the most reliable guide as to your right to carry know-how from one employer or client to another. You should also be guided by how the courts have defined trade secrets. Here is a timely summary of such decisions (p. 120), by attorney Albert W. Gray.

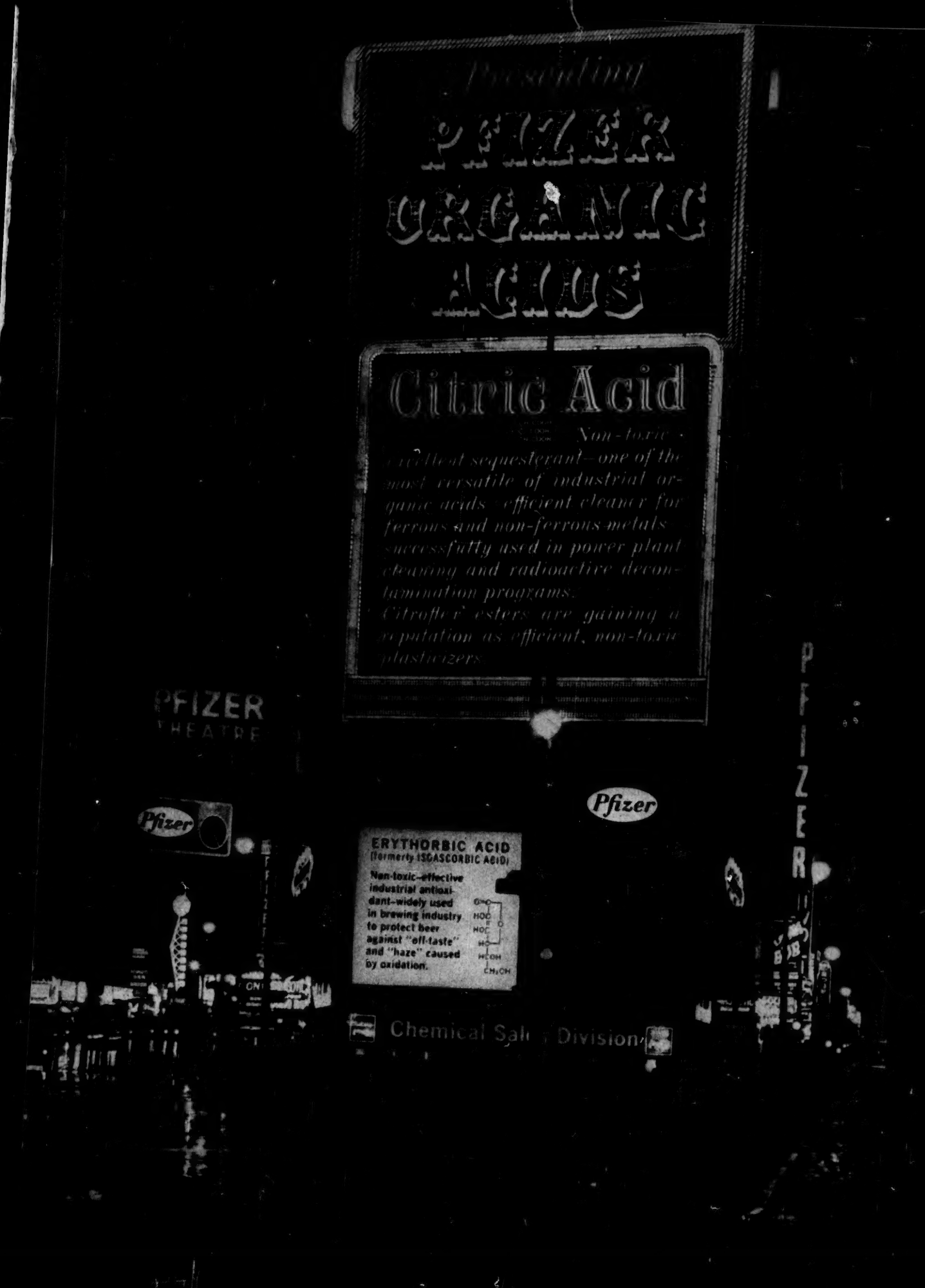
CHEMENTATOR, INDUSTRY & ECONOMIC NEWS

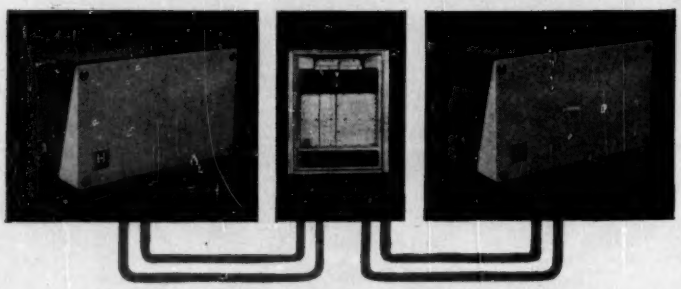
With this first issue of the new year, we are putting into effect two changes in our coverage of industry developments:

• By special arrangement with our printer, we have increased the timeliness of *Chementator* by six days. This department—already tops in readership—is now more valuable than ever with its added freshness (p. 33).

• Our Chemical Economics department has been merged with Industry News to provide expanded coverage of Industry & Economic News (p. 42). In the past few years, the material appearing under the Chemical Economics banner has taken on a more timely character in order to keep you better informed on how current trends in the marketplace relate to new developments in processes and technology. Our new setup acknowledges the fact that supply and demand, cost and price, influence all that's happening in the CPI.

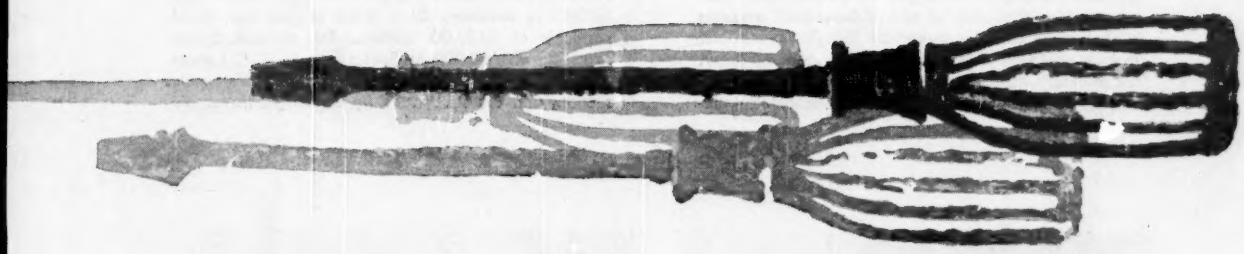

GLUCONIC ACID
PFIZER
TARTARIC ACID
COOH
HCOH
HCOH
COOH
Non-toxic — excellent sequestrant — salts widely used in metal cleaning and plating, textile printing, and blueprinting, plus a host of related industries.
OXALIC ACID
FOR VERSATILE ORGANIC ACIDS!
PFIZER
Low toxicity — reactive monomer
ITACONIC ACID
Carboxyl groups can add adhesion, solubility and stability to copolymers. Other Itaconic Monomers (Dimethyl and Dibutyl) commercially available.
CH2=C-COOH
CH2-COOH
CHAS. PFIZER & CO., INC.
PRESENTS
TARTARIC ACID
OXALIC ACID

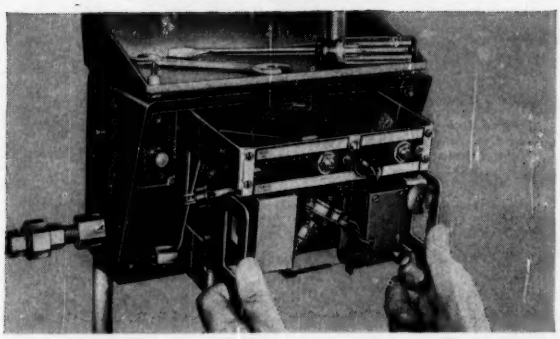

Presenting
PFIZER
ORGANIC
ACIDS
Citric Acid
Non-toxic
excellent sequesterant—one of the most versatile of industrial organic acids efficient cleaner for ferrous and non-ferrous metals successfully used in power plant cleaning and radioactive decontamination programs.
'Citrofle x' esters are gaining a reputation as efficient, non-toxic plasticizers
PFIZER
THEATRE
Pfizer
Pfizer
ERYTHORBIC ACID
(formerly ISOASCORBIC ACID)
Non-toxic—effective industrial antioxidant—widely used in brewing industry to protect beer against "off-taste" and "haze" caused by oxidation.
Chemical Sale Division
PFIZER



***ElectriK Tel-O-Set*—the true 2-wire system**

NO STAND-BY SUPERVISION





No stand-by supervision needed when you install an *ElectriK Tel-O-Set* Control System. Installation crews never have to open an instrument cover to hook up the line . . . instrument crews never have to touch an outside line to service an instrument.

It's all in the *Tel-O-Set* connection system. All process connections are entirely isolated from the inside of the instrument case. Installation crews can mount, pipe, and wire the various *Tel-O-Set* instruments without removing the cover. Instrument chassis can be removed for servicing without breaking any external process or electrical connection. Standardized parts, together with extensive use of quick-connect and plug-in design, minimize downtime and reduce spare parts inventory.

And there's more to the *ElectriK Tel-O-Set* economy story. Specifically, there's no external power required at any field-mounted *Tel-O-Set* instrument. Line power connection is made only at the receiver. Two-wire d-c transmission reduces installation costs and eliminates shielding problems. Also, the 4-20 milliamp signal range of the system gives a live zero and permits the use of the most reliable transistors available. The d-c signal can be fed into data handling systems and millivolt-actuated instruments . . . can be easily transduced to a standard 3-15 psi pneumatic signal to operate existing pneumatic systems.

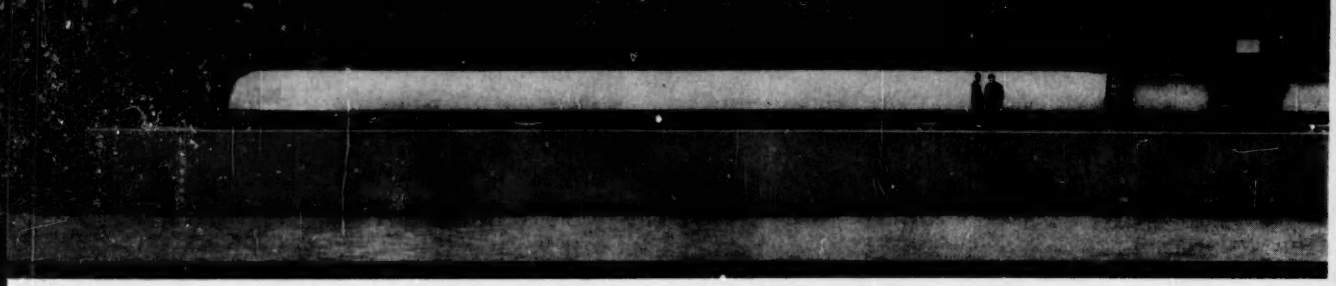
Take a new look at your control problem with the *ElectriK Tel-O-Set* System in mind! Get the complete economy story from your local Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, 21 Penn Street, Fall River, Massachusetts.

Honeywell

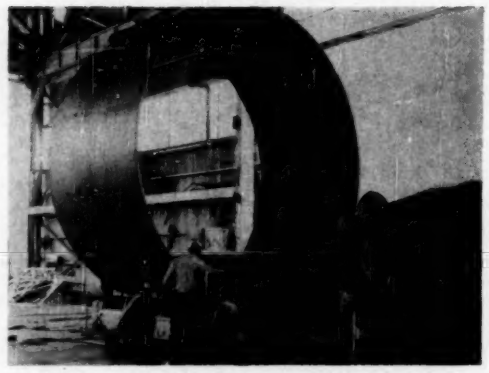
First in Control

SINCE 1885

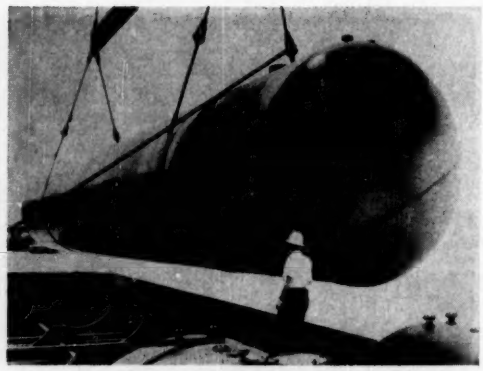
speaking of



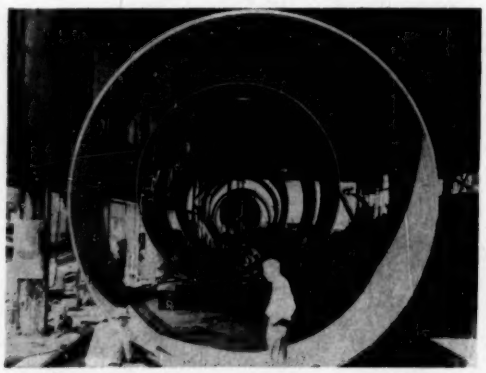
You are looking at the largest barge of its kind ever constructed. It is one of two independent pressure tank barges built by Avondale Shipyards, Inc., for the Union Texas Natural Gas Corporation of Tulsa, Oklahoma. Measuring 273'x41'x12'16", the open hopper barge contains four saddle mounted independent cargo tanks each 112'9½" in length and 16'3⅛" in diameter. Each pressure tank has liquid capacity of 165,000 gallons, for a total barge capacity of 660,000 gallons. The " barges have a 32' forward rake section, an 8'6" after rake section, and are subdivided by watertight transverse



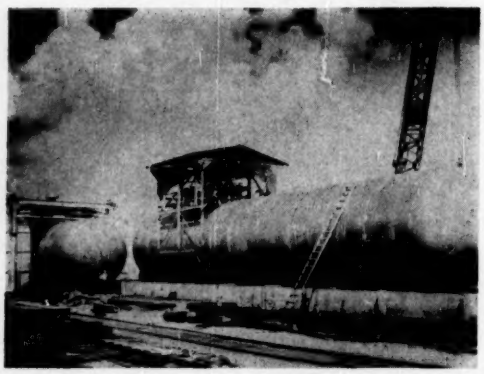
Cold rolling 1-9/16" steel plate to form a 16' 3⅛" dia. pressure tank section. Bertsch roll capacity is 4½", largest of kind in Gulf-South.



One of four 165,000 gallon cargo tanks being lowered into saddles in barge hull. Lifting device (not shown) has 600-ton capacity.



Tank sections being fabricated in one of Avondale's structural shops.



Foreground, pressure tank nearing completion on aligning platten, background, left, completed tank being stressed relieved in Avondale's 18' x 18' unlimited length stress relieving furnace.

big barges...

bulkheads fore and aft of the tanks and in between each pair of tanks.

Each cargo tank was fabricated of 1-9/16" shell plating, cold rolled to 16'3⅛" diameter on the largest Bertsch plate roll of its kind in the Gulf South.

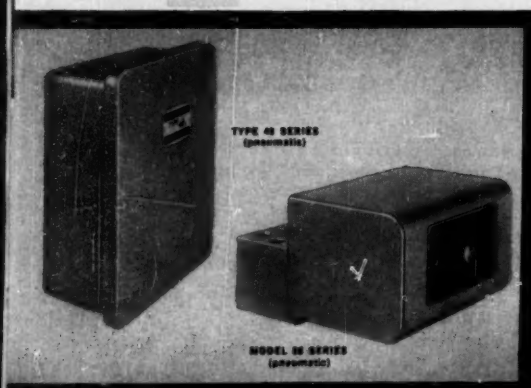
The cylindrical sections were joined by automatic welding. Certified for the transportation of liquified petroleum of 250 PSI on the Inland Water ways, and classified A-1 pressure tank barges for river service, the contract completion is an excellent example of Avondale Shipyards' fabricating abilities.

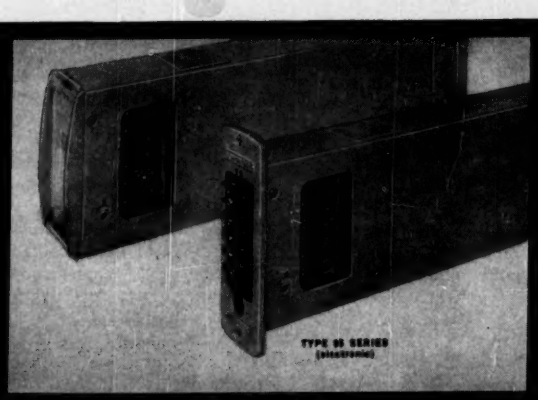
The economies being effected today through the movement of petrochemical products by water are of prime profit importance. And important to your expansion into this area is the selection of a barge builder. Avondale Shipyards offers years of specialized experience, complete design, engineering and fabricating facilities, proof of ability through the hundreds of highly successful Avondale-built petrochemical barges now operating for many companies.

AVONDALE SHIPYARDS, INC.

P. O. BOX 1030 • PHONE UNiversity 6-4561 • NEW ORLEANS 8, U.S.A.

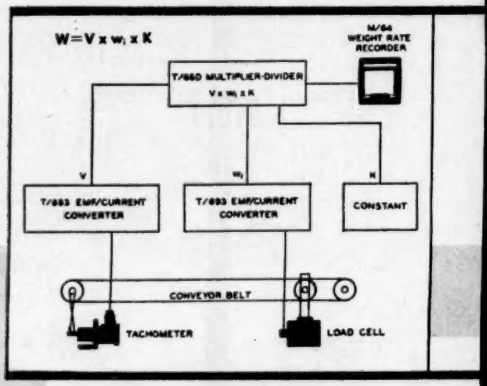
new low-cost Foxboro simplify automation





FOXBORO ANALOG COMPUTING STATIONS

▶ TYPICAL



WEIGHT RATE COMPUTATION

Gives operator continuous recording of actual weight of materials being conveyed by belt. For example, T/66D Multiplier-Divider calculates actual weight-rate from load cell and belt speed measurements.

Analog Computing Systems of process mathematics

both pneumatic and electronic units available

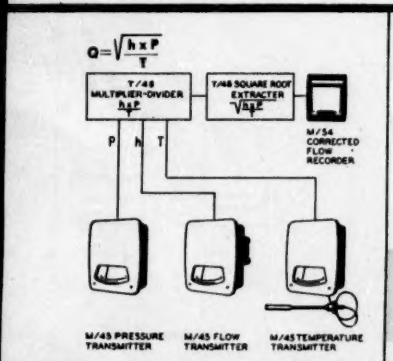
Analog computing systems have been known and used for years. Yet their potential for increasing process efficiency has hardly been scratched.

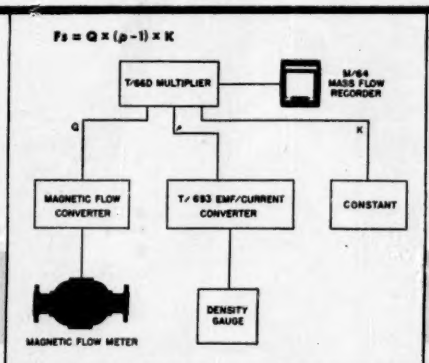
Just look what they can do! Continuous calculation of all the arithmetic functions: addition, subtraction, multiplication, division, square root extraction — in any combination. And all done automatically by a single packaged system.

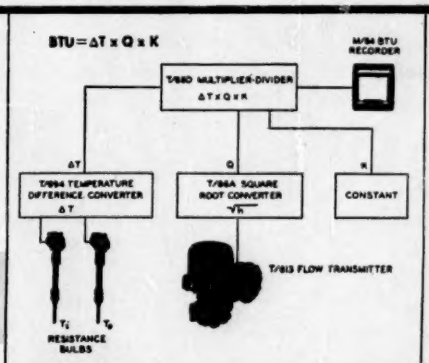
And look how it simplifies the operator's job. Instantaneous calculation . . . with records to prove it. No slide rules, no interpolation, no planimeters — and most important — no mistakes.

Because Foxboro Analog Computer Systems are relatively low-cost ($2500-5000 average) you can "spot" them about your plant for maximum efficiency. Or, they can be grouped together at a central location to solve more complicated equations. Pneumatic and electronic systems available.

CALCULATIONS MADE WITH FOXBORO ANALOG COMPUTING SYSTEMS







GAS FLOW COMPUTATION

In common use in the Gas Industry to compensate gas flow readings for changes in line temperature and static pressure. In the pneumatic system shown here, the Foxboro T/46 Multiplier-Divider and the Square Root Extractor allow operator to read corrected flow directly.

MASS FLOW COMPUTATION

Calculates dry weight of a slurry flowing through a pipeline. In this electronic system, flow rate and density measurement are multiplied together with a Foxboro T/66D-1 Multiplier. Operator can then read flow directly in Dry-Tons-Per-Minute.

BTU COMPUTATION

Determines actual amount of heat being introduced to, or removed from, a process. Electronic system shown uses a Foxboro T/66D Multiplier-Divider to produce a signal equal to product of flow and temperature difference. Operator reads directly in Btu's.

WHAT CALCULATIONS WOULD YOU LIKE TO AUTOMATE? ➔

FOXBORO
REG. U.S. PAT. OFF.

The Foxboro Company, 361 Neponset Ave.
Foxboro, Mass.

I have a process computation I should like to automate. Can a Foxboro Analog Computing System do it for me?

My process is.....

I want to compute.....

.....

Name.....

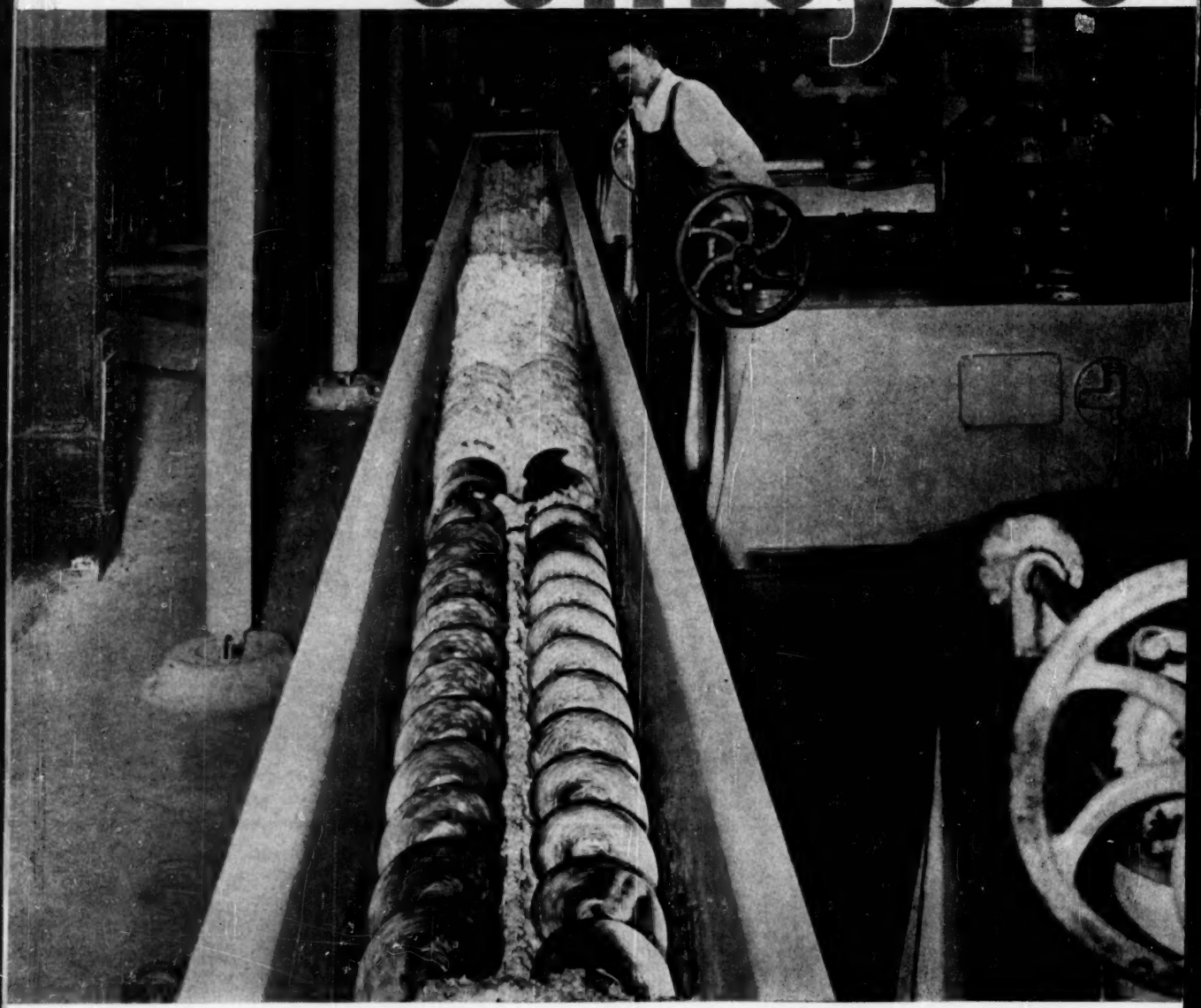
Position.....

Company.....

Address.....

City.....**State**.....

LINK-BELT conveyors



SCREW CONVEYORS—Easily adapted to congested locations . . . operate horizontally, vertically or inclined. Link-Belt provides all components for a complete screw conveyor line. Exclusive optional *Quik-Link* feature permits fast, easy removal of any conveyor section without disturbing other components.

The last word in value from the first name in conveyors

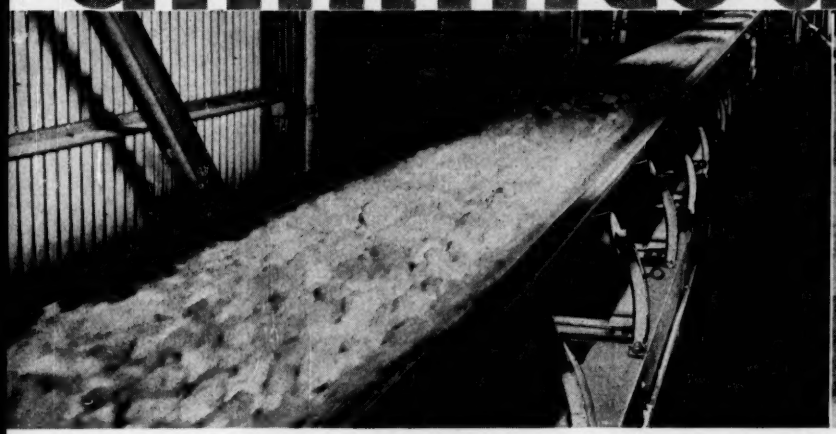
When it comes to your materials handling needs, it is a matter of sound economics to depend on Link-Belt, builders of industry's most complete conveyor line. In addition to this broad range of line, which permits unbiased recommendations, Link-Belt offers *quality*—achieved through engineering skills, manufacturing scope and research . . . *"experience unlimited"* in the materials handling field.

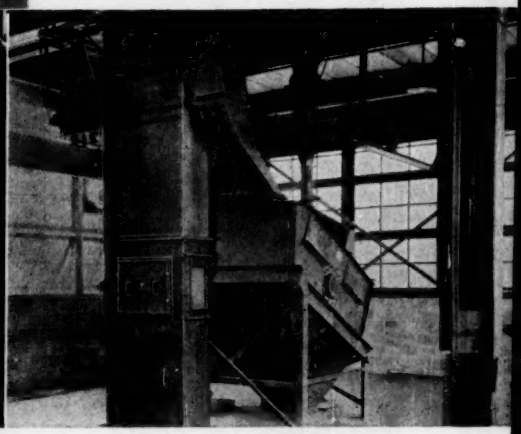
Also important, Link-Belt can provide *complete* handling systems . . . patterned exactly to your requirements with a background of more than 80 years of conveyor specialization. Our engineers are familiar with the particular handling needs of every industry. It's more than likely they have met —and solved—many problems similar to yours. We will design, equip and erect your entire installation . . . and accept full responsibility for its successful operation.

For full information—on single components or complete systems—large or small—contact your nearest Link-Belt office. Catalogs covering all conveyors are available on request.

unlimited

The line that means savings, whether handling parts or bulk materials, finished products or units



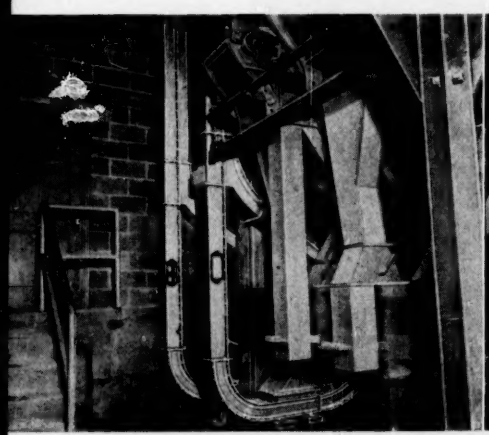


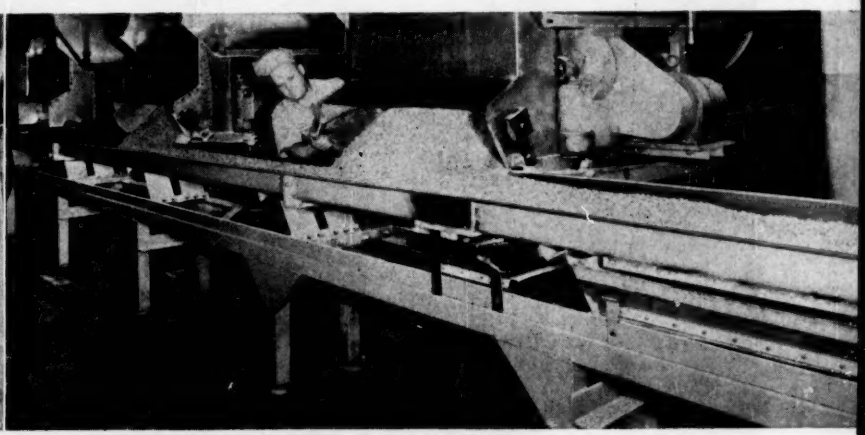
BELT CONVEYORS—Link-Belt serves as a single source for design, equipment and erection of *Job-Engineered* belt conveyors for small or large tonnages, for routes of any length. Link-Belt engineers have the selection advantage of industry's most comprehensive idler line—plus a broad range of pulleys, drives, terminal machinery and auxiliary equipment. Husky, *Pre-Bilt* sectional belt conveyors are also available from Link-Belt.

BUCKET ELEVATORS—Unlimited solutions to vertical or inclined movement of a wide variety of materials—bulk or parts. Fourteen types in four basic designs are fabricated from Link-Belt designed and integrated components—factory aligned for low-cost installation, smooth performance.

BULK-FLO—It's a feeder. It's an elevator. It's a conveyor. All in one unit. Operates horizontally, inclined or vertically. Conveying medium consists of an endless chain with cross flights operating in a close fitting casing. For a wide range of granular, crushed or pulverized materials.

OSCILLATING CONVEYORS—Whether handling fines or granules, chunks, parts or metal chips, Link-Belt's four types of oscillating conveyors—Flexmount, Coilmount, Heavy-duty Coilmount or Torqmount—provide surge-free movement of materials. All types feature *full-time positive action*, yet operate as near to *natural frequency* as possible to minimize power requirements.





LINK-BELT

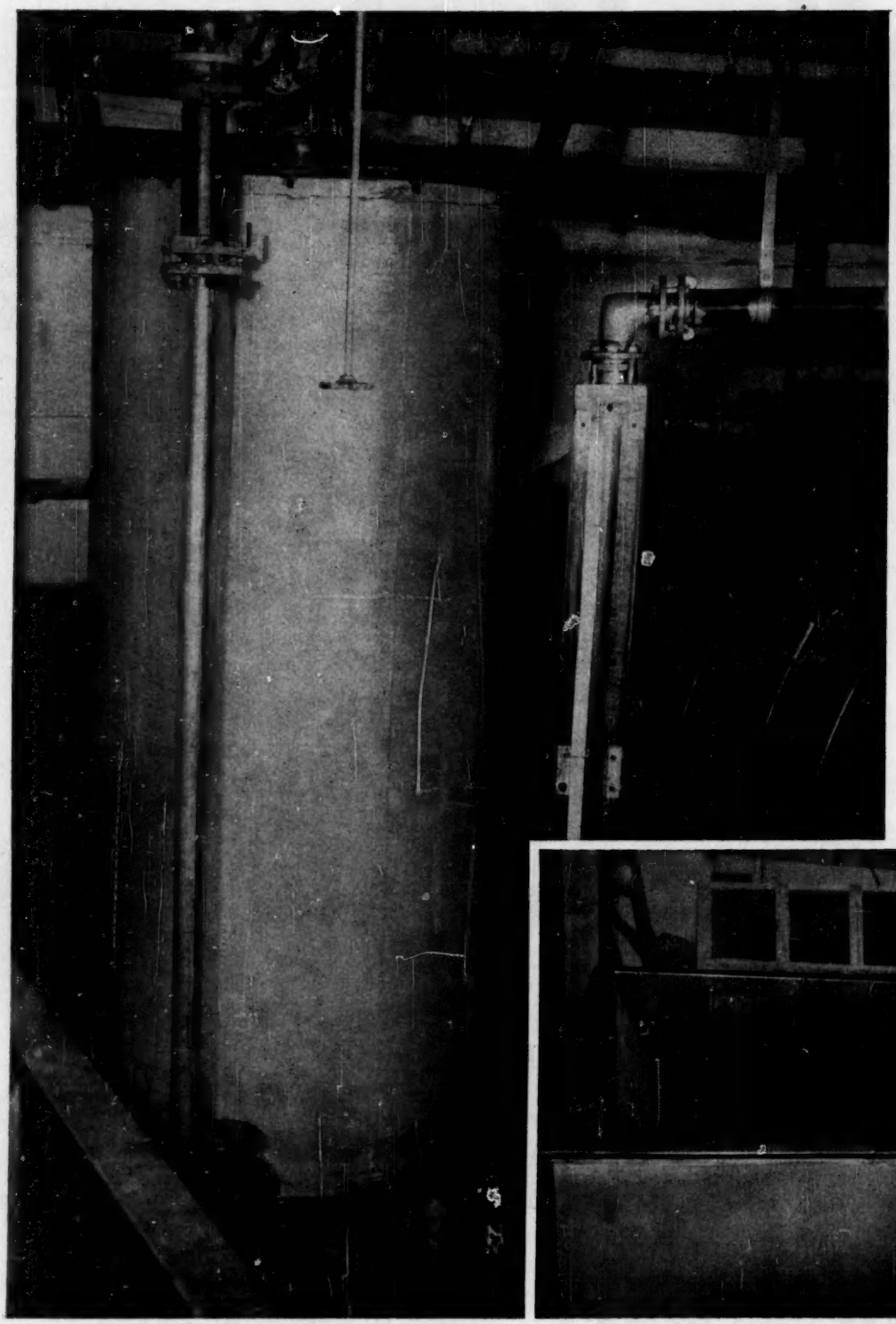
15,580

CONVEYING AND ELEVATING EQUIPMENT

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses and District Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World.

Keeping production on the move in every industry

Apron conveyors
Arm and tray elevators
Belt conveyors
Bucket elevators
Bucket elevators-conveyors
Bulk-Flo
Car-type conveyors
Chain conveyors
Circular carrier conveyors
Drag conveyors
Flight conveyors
Flite-Flow conveyors
Oscillating conveyors
Power-and-free conveyors
Pusher chain conveyors
Scraper conveyors
Screw conveyors
Sidekar-Karrier conveyors
Skip hoists
Slat conveyors
Trolley conveyors
Trukveyors



Courtesy, Electro Chemical Engineering Co., Emmaus, Penna.

USE IT WITH CONFIDENCE. This Penton-lined tank installed in a large East Coast chemical plant has already celebrated its first anniversary of trouble-free service. Used for off-gas condensate, it handles a mixture of 15% HCl and 69% acetic acid in water, at temperatures ranging from 170°F. to 212°F.

Courtesy, Buckley Iron Works, Dorchester, Mass.

ECONOMICALLY APPLIED. Penton linings for large tanks and processing vessels are achieved by the use of adhered sheet ranging in thickness up to 40 mils, applied to low-cost metal substrates with a straightforward adhesive system and conventional gas welding.

PENTON® AT WORK...TANK LININGS

In processing systems, it's what's inside that counts

Penton linings readily convert carbon steel tanks into vessels capable of handling corrosive liquids at elevated temperatures. Thus it is now possible to get corrosion resistance *inside* chemical processing systems, where it really counts, without recourse to the high-cost materials previously required in many use areas.

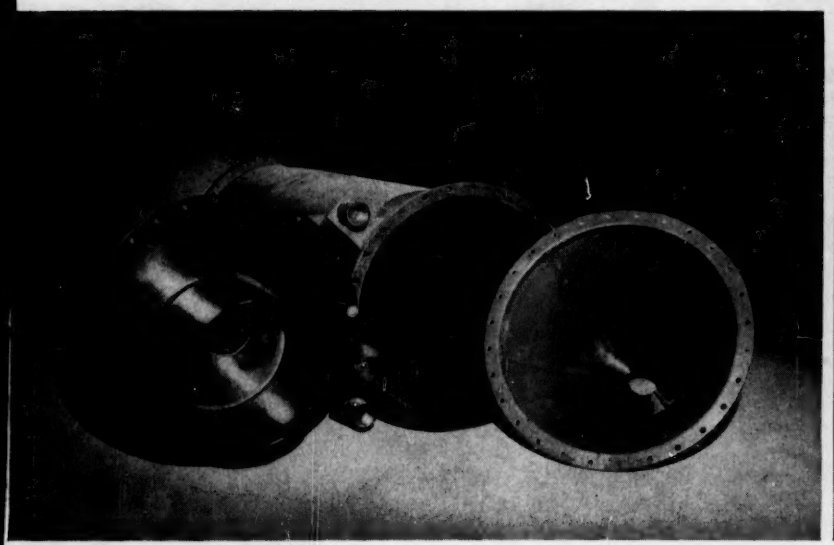
Today there is a qualified tank liner in your area, experienced with Penton, and able to employ it to meet your specifications. Because Penton resists more than 300 common reagents, at temperatures far in excess of those possible with most conventional lining materials, it can offer you important savings in original cost, maintenance, and in many instances permit higher processing temperatures for increased yields.

Want more information on Penton tank linings? Write for your copies of "The ABC's of Penton for Corrosion Resistance," and "The Penton Buyer's Guide," which includes a complete listing of Penton tank liners, and producers of other types of Penton processing equipment.

Cellulose Products Department
HERCULES POWDER COMPANY
INCORPORATED
Hercules Tower, Wilmington 99, Delaware

CP61-1

Penton sheet used in fabricating tank linings illustrated on these pages manufactured by Garlock, Inc., Camden, N. J.



Courtesy, Electro Chemical Engineering Co., Emmaus, Penna.

Courtesy, Mercer Rubber Corporation, Little Ferry, N. J.

TAILORED TO YOUR SPECIFIC NEEDS. The complex shapes shown here demonstrate the versatility of Penton linings applied to low-cost metal substrates for high temperature corrosion resistance. Penton-lined pipe and fittings, valves, meters and pumps can be used in conjunction with such vessels to supply a complete anticorrosion processing system based on Penton.

CLARK Centrifugal Compressors Assure 100% Availability

Typical Clark Isotemp Compressor installation with synchronous motor drive and gear located on mezzanine level.

In air separation plants throughout the world, Clark Horizontally-Split Centrifugal Oxygen Compressors are operating in 100% service. Because the Type HS Compressors are literally maintenance free, standby units have not been required. The performance of these machines has been outstanding with safety, dependability and efficiency being among the features "best liked" by operators.

Now, another centrifugal compressor has been added to the Clark line of air separation compressors. The new Clark Isotemp Centrifugal Air Compressor has been designed to provide highest purity, primary 110 psi. air for tonnage oxygen plants. Like the Type HS Oxygen Compressors, the *Isotemp* is designed for 100% availability. It incorporates many of the design features found to be so effective in the oxygen machines.

A key feature of the Clark Isotemp Compressor is the system of integral intercoolers. Built into the base of machine, they form a compact unit-engineered package. An unusually high efficiency over a wide operating range is produced by intercooling between stages, the use of closed-type impellers and volute diffusers. Single-case, horizontally-split design assures maximum accessibility and eliminates alignment problems.

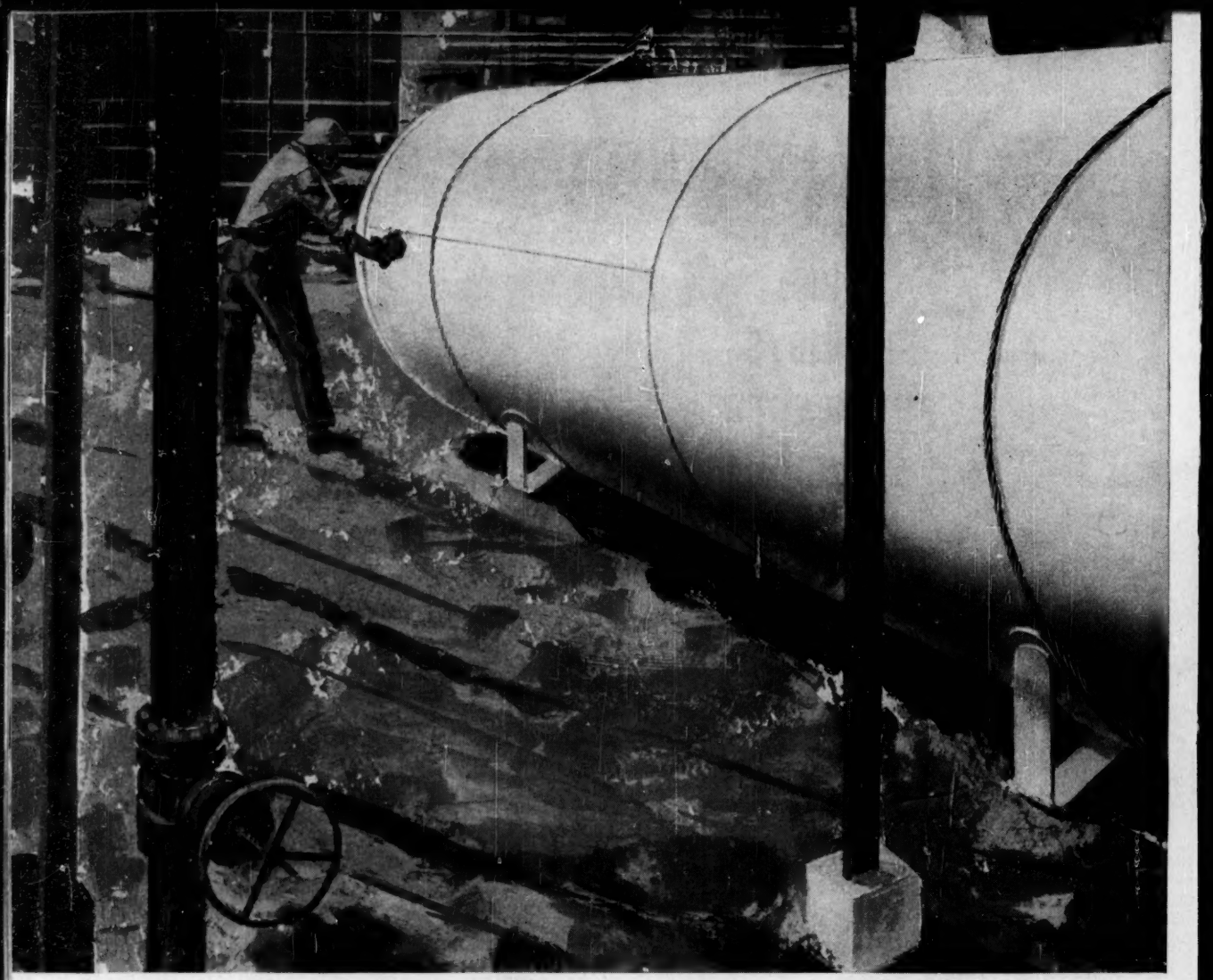
If you need high purity compressed air in large volumes, the Clark *Isotemp* will provide substantial savings in capital investment, space, foundation requirements, maintenance and operating costs. The *Isotemp* is built in seven frame sizes in packages with capacities ranging from 5000 to 50,000 cfm and more. Clark Oxygen Compressors are available in matching frame sizes. Both the Isotemp and Type HS units can be driven by synchronous motors, induction motors or turbines.

For data on Clark Centrifugal Compressors and Reciprocating Compressors consult your nearest Clark representative or write for Bulletin 175 on Isotemp Compressors, Bulletin 150 on Centrifugal Oxygen Compressors or Bulletin 160 on Clark Reciprocating Process Compressors.

CLARK BROS. CO.
OLEAN, N.Y.

ENGINES
COMPRESSORS
GAS TURBINES

CLARK ENGINES COMPRESSORS GAS TURBINES
DRESSER INDUSTRIES INC.
OIL • GAS • CHEMICAL
ELECTRONIC • INDUSTRIAL



$3,267 could be saved by building this

Here is a design for an LP gas storage tank that hasn't been built yet. It is 20 feet long and 72 inches inside diameter.

The tank was designed by the Consolidated Western Division of United States Steel. Costs were estimated for the tank using structural carbon steel (A-285) and two other ways using USS "T-1" Constructional Alloy Steel, code and non-code, as indicated in the tables.

The design stress for one of the USS "T-1" Steel tanks is 50,000 psi. This is considerably higher than is permitted by the ASME code Case 1204-4.

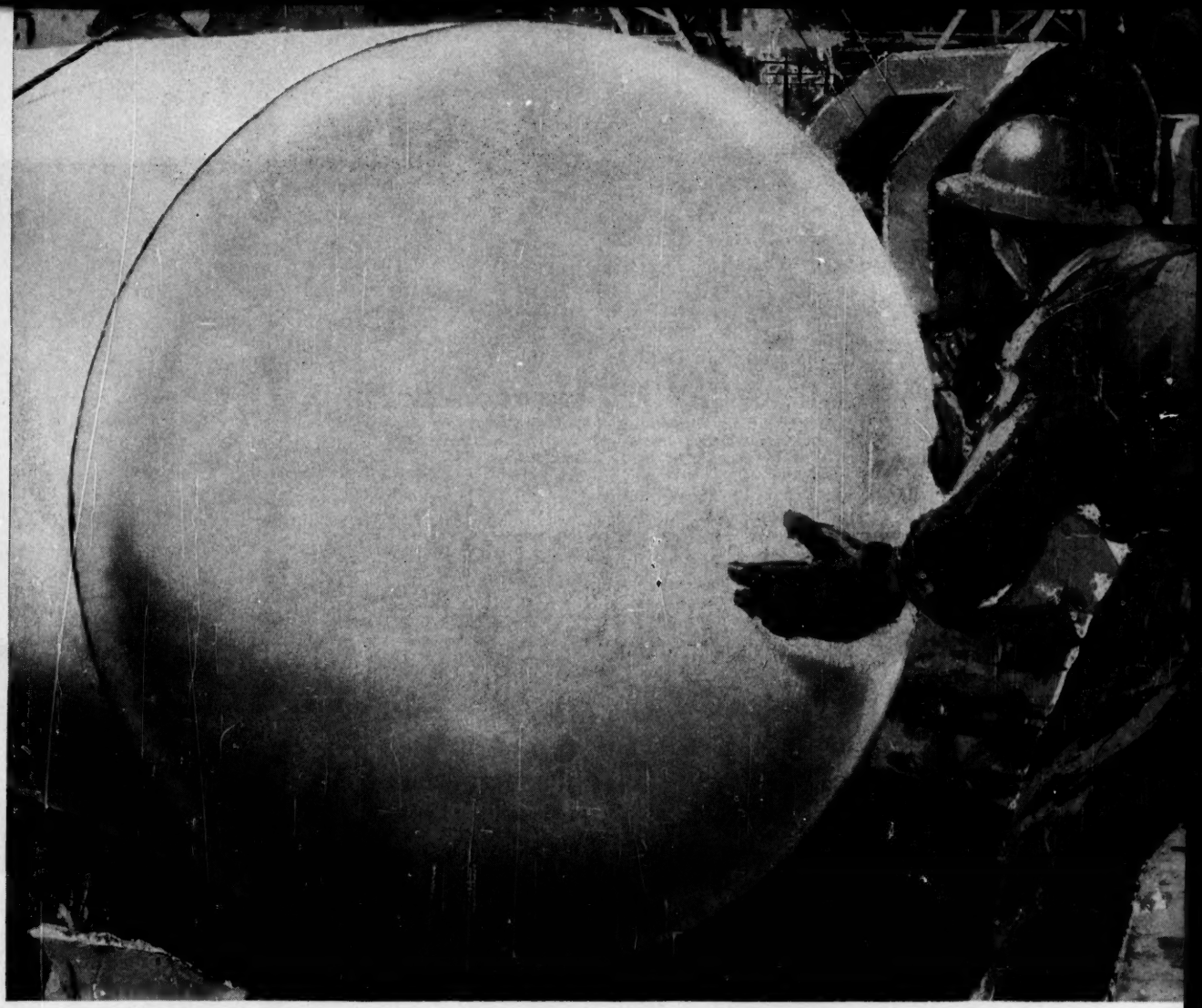
USS "T-1" Steel Construction costs less. As you can see from the tabulation, the maximum saving in total costs with USS "T-1" Steel (non-code) is $3,267 (Column 3) compared with carbon steel and amounts to $1,065 when the "T-1" Steel "code" vessel (Column 2) is compared with A-285 Grade C. The difference between the "T-1" Steel "code" and "non-code" vessel costs is a substantial $2202.

The big savings come from the fact that plate thickness can be reduced substantially because of the great strength of USS "T-1" Steel (100,000 minimum yield strength). This makes the cost of the steel lower, in the one case, in addition to reducing the fabrication and freight costs. For the price of 5 carbon steel tanks, 6 "T-1" Steel tanks conforming to ASME 1204-4, or 9 tanks designed to 50,000 psi stress (Column 3) could be built!

Lower maintenance, too! USS "T-1" Steel has four times the resistance to atmospheric corrosion as structural carbon steel. Research has shown that paint lasts longer on steels of this nature—and intervals between paintings are much greater.

Retains toughness down to —50°F. Even at low temperatures, USS "T-1" Steel retains its strength and toughness. It also has high resistance to impact abrasion and is weldable by the usual methods. These plus values make USS "T-1" Steel ideal for other equipment besides tanks—machinery hauling trailers, truck tanks, offshore rigs and other equipment that must be built stronger and lighter. Write for a copy of our booklet, "Designing and Fabricating Structures of USS 'T-1' Steel," United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS and "T-1" are registered trademarks



LP gas storage tank from USS "T-1" Steel

Cost Advantages of USS "T-1" Steel

Material Code Allowable Stress Joint Efficiency	#1 A-285 Gr.C Firebox 1958 ASME Code 13,750 PSI 100% X-ray Stress Relief	#2 "T-1" Firebox ASME 1204.4 28,750 PSI 100% X-ray Stress Relief	#3 "T-1" Firebox Non-Code 50,000 PSI 100% X-ray No Stress Relief
1. Thickness of shell plates	$1\frac{11}{16}$" Nominal	$\frac{25}{32}$" Nominal	$\frac{7}{16}$" Nominal
2. Thickness of shell heads	$1\frac{11}{16}$" Nominal	$\frac{13}{16}$" Nominal	$\frac{1}{2}$" Nominal
Weight	7310#	3484#	2158#
3. Weight of steel required (excl. heads)	26586#	12150#	6767#
4. Type of electrodes used for welding	AWS-E-7018	AWS-E-11018-G	AWS-E-11018-G
	491#	96#	48#
5. Cost			
a. steel cost	$3,394	$3,541	$2,207
b. fabrication cost—pressure vessel	2,670	1,650	1,014
c. freight—inbound—(delivered steel)	992	469	273
d. erection cost	None	None	None
e. 6" ϕ nozzle-installed	270	601	565
6. Total Cost F.O.B. Shops—Los Angeles, Calif.	$7,326	$6,261	$4,059
Over-all Savings with USS "T-1" Steel	.....	$1,065	$3,267

This mark tells you a product is made of modern, dependable Steel.

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
National Tube—Pittsburgh
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

Noel M. Champion *(left), Chief Engineer, Armour Agricultural Chemical Company, discusses a technical problem with* Robert L. Kietzman, *Sales Engineer, The Cooper-Bessemer Corporation, St. Louis District Office.*

How Cooper-Bessemer service helps keep the ammonia flowing

At Armour Agricultural Chemical Co., Crystal City, Missouri, nine Cooper-Bessemer compressors play key roles in the manufacture of ammonia products. Round the clock, for five years, these units have given exceptional performance under the rigors of such problems as handling pressures up to 9000 psi.

The performance of these C-B compressors has been backed by Cooper-Bessemer engineers in the St. Louis area and in Mt. Vernon, contributing helpful service for these high-pressure operations.

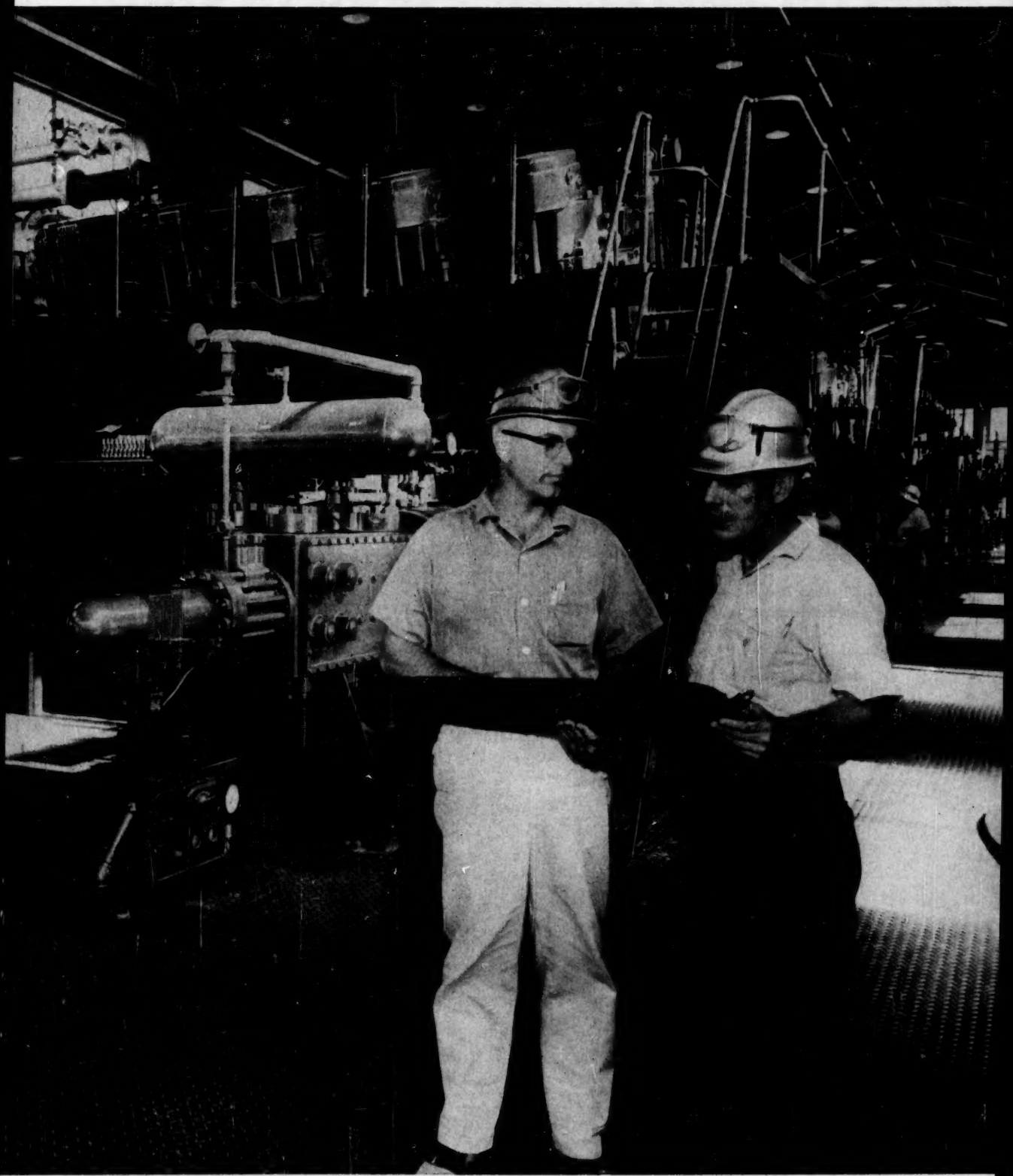
Cooper-Bessemer engineers will gladly help *you* plan compression facilities, and demonstrate how this unique service works for your benefit. Call the nearest office.

BRANCH OFFICES: Grove City • New York • Washington • Gloucester Pittsburgh • Detroit • Chicago • Minneapolis • St. Louis • Kansas City • Tulsa New Orleans • Shreveport • Houston • Greggton • Dallas • Odessa • Pampa Casper • Seattle • San Francisco • Los Angeles • *SUBSIDIARIES:* Cooper-Bessemer of Canada, Ltd.... Edmonton • Calgary • Toronto • Halifax Stratford • C-B Southern, Inc.... Houston • Cooper-Bessemer International Corp.... New York • Caracas • Anaco • Cooper-Bessemer, S.A.... Chur, Switzerland • The Hague, Netherlands • Mexico City • The Rotor Tool Company... Cleveland

Cooper Bessemer

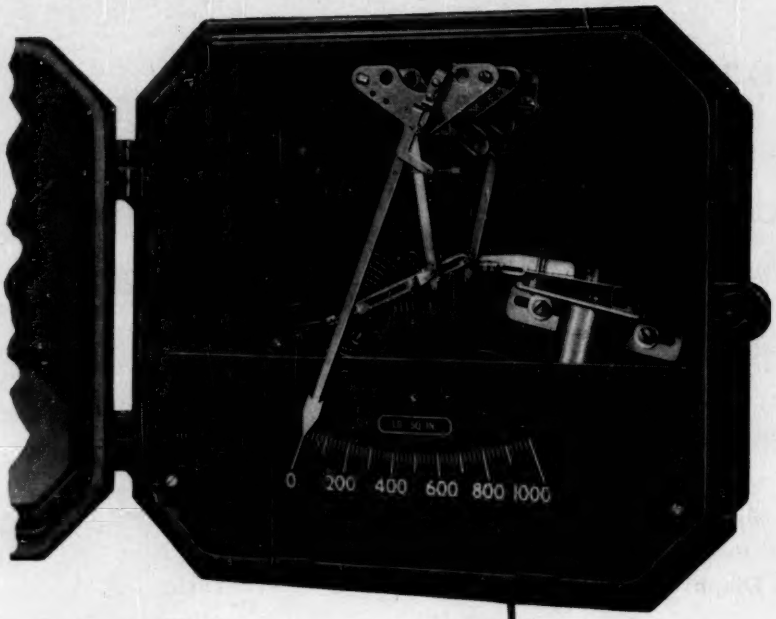
GENERAL OFFICES: MOUNT VERNON, OHIO

ENGINES: GAS • DIESEL • GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE, TURBINE OR MOTOR DRIVEN

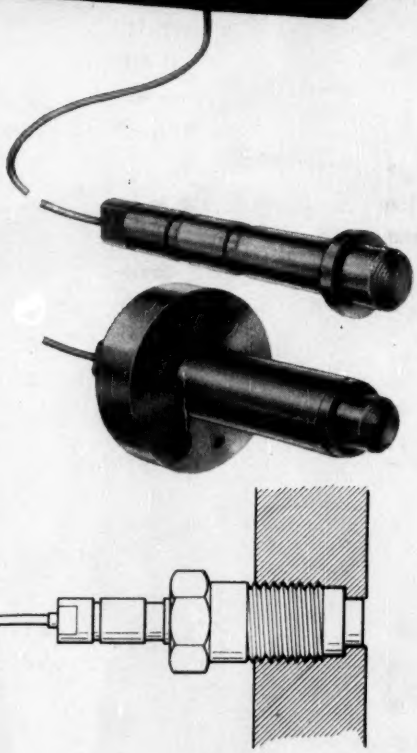


Noel M. Champion *(left) and* Thomas H. Ferebee, *Supt. Ammonia Plant. In background are two GMWA-10, four GMWA-8 and one GMWA-6 engine driven compressors for compression of air, natural gas, synthesis gas and ammonia. Armour also has two FM compressors for ammonia recirculators.*

Better *Taylor* elements for



The "Button Diaphragm" Volumetric Pressure Element has a sensing head less than an inch in diameter and practically insensitive to process heat. It is available in three types of construction: *Type 90*—with rigid stem 5⅜" long and with grooves for jack-out collar; *Type 91*—same with flange built on system; *Type 92*—same with hub built on system. Capillary connection permits "off-press" location of the instrument. Type 90 shown here is connected to a Taylor 726T Universal Electronic Indicating Transmitter.



Type 90

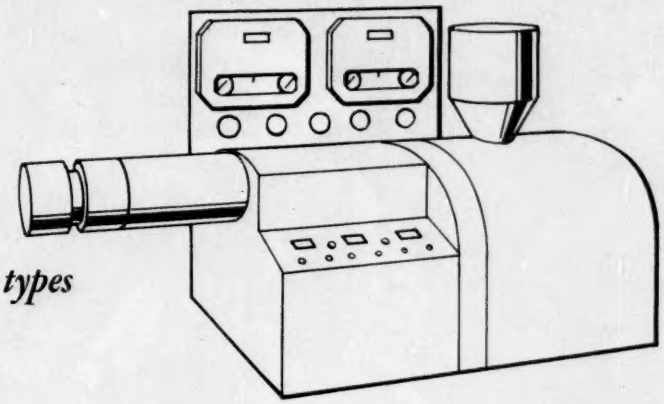
Type 91

Type 92

Taylor Instruments

high pressure measurement

"Button Diaphragm" Volumetric Pressure Systems . . . *ideal for high pressure extruders of all types*



For high pressure measurement in the extrusion of synthetic fibres, plastics, films, etc., Taylor all-welded closed systems are far superior to anything previously used. The "Button Diaphragm" type shown at left has a sensing head less than 1" diameter. It is available in a variety of ranges from 0-400 psi to 0-15,000 psi. It gives accurate pressure measurement at operating temperatures up to 1500°F. It has these advantages:

Less sensitive than a strain gage to high process temperatures.

Eliminates troublesome leakage, due to sturdy welded construction.

Easier to install and maintain.

Systems are factory assembled, filled and calibrated, insuring accurate measurement and eliminating the necessity of filling and adjusting in the field. They can be used with any Taylor pressure indicators, recorders, controllers or transmitters having Bourdon spring actuation.

Taylor Volumetric Pressure Systems are also ideally suited for pressure measurement of difficult substances, such as slurries, corrosive fluids, colloidal suspensions or liquids that tend to jell in small pipes.

Ask your Taylor Field Engineer, or write for **Bulletin 98398.** Taylor Instrument Companies, Rochester, New York, or Toronto, Ontario.

Other types of all-welded volumetric pressure element available for pressures up to 1500 psi. Write for **Bulletin 98365.**

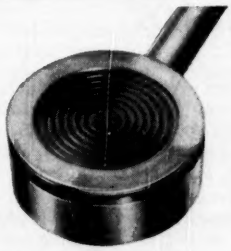


Fig. 1—Type 107

Fig. 2—Type 104

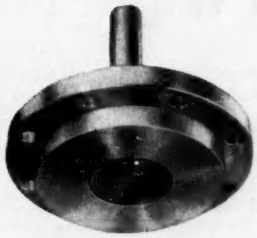


Fig. 3—Type 105

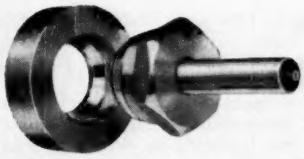
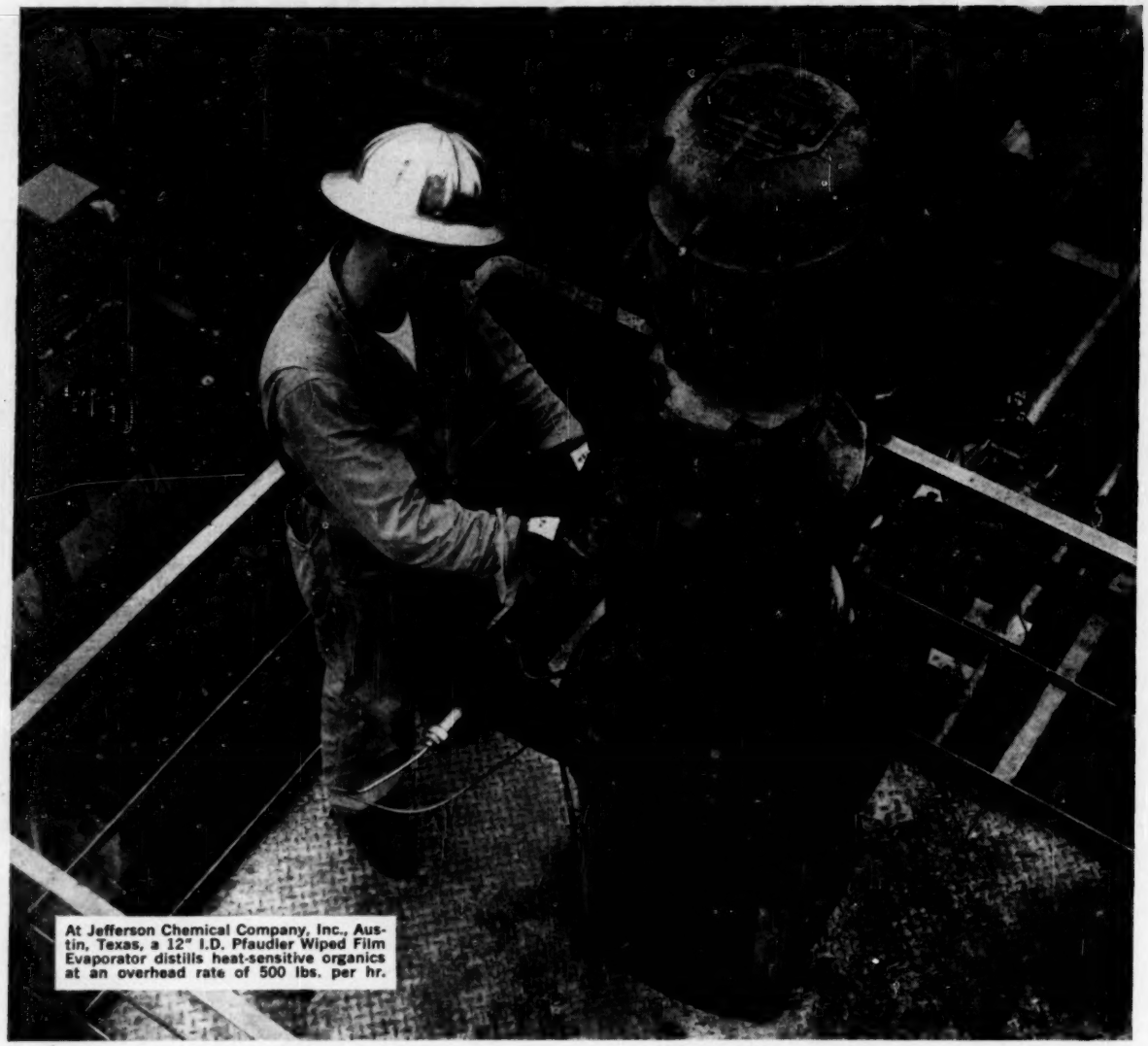


Fig. 4—Type 106

MEAN ACCURACY FIRST

FLUIDICS* AT WORK



At Jefferson Chemical Company, Inc., Austin, Texas, a 12" I.D. Pfaudler Wiped Film Evaporator distills heat-sensitive organics at an overhead rate of 500 lbs. per hr.

HEAT-SENSITIVE ORGANICS NO PROBLEM with this Wiped Film Evaporator

Jefferson Chemical distills heat-sensitive, high-boiling organics in it with yields of 42 lbs. per hr. per sq. ft. of heat transfer area.

They operate their Pfaudler® Wiped Film Evaporator at 2mm Hg and report unit is simple to clean and maintain. "Actually the over-all performance of this evaporator is superior to any expectations we had," states Jefferson Chemical.

Mechanical wiping. A *true* wiped-surface evaporator, it uses centrifugal force to hold four free-floating wipers in contact with the internal heated wall. Slots in the wipers *prevent* curl and spread product in a thin, uniform film to assure full use of heat transfer area.

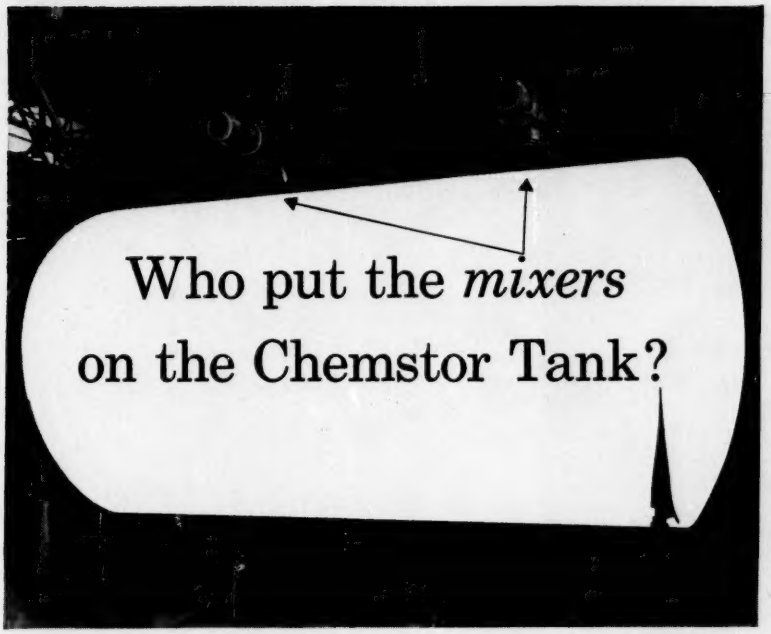
This construction also makes the Pfaudler unit well suited to handling products that are highly viscous or low in thermal conductivity.

Internal condenser. The "U"-tube bundle is *inside*, so there's a negligible pressure drop between evaporating and condensing surfaces. With an internal condenser, you also need less floor space and save on ductwork, piping and installation costs.

Functional simplicity. There's no bottom bearing in any Pfaudler evaporator, so you don't worry about trouble or maintenance. With some products you clean by running a solvent through. For visual inspection or more thorough cleaning, just break vacuum and lift drive, top head, and rotor out as a single unit.

Choose from 12" I. D. models (4, 9 or 12 sq. ft. of evaporating area) or 36" I. D. models (30, 50, 75 and 100 sq. ft.). If you need larger sizes, we make them on a custom basis.

Test the performance of *your product* in the Wiped Film Evaporator at the Pfaudler Test Center. Or get more details from Bulletin 991. Write to the address shown on the facing page.



We did. Which should interest you if anything you store tends to *separate out* on standing.

Agitation as an integral part of Pfaudler Chemstor Tanks should prove particularly attractive if the products you handle are *corrosive,* since the tanks are of Glasteel—glass inside, steel outside—and resist attack from all acids (except HF) and most alkalies.

Initially, you will be able to get 32" or 36" turbines installed in 5-, 10-, or 15-thousand-gallon tanks operating at 55 rpm with our 4TW drive.

Chemstor Tanks are an excellent investment for two reasons. With any corrosive, unusually *long service life* is the payoff. And in sizes from 10- to 35,000-gallons, regardless of what you store, savings are immediate, since the *costs are lower* than for stainless.

Glasteel is hard, nonporous and smooth, so there's little chance for build-up, even with sticky substances. And the inert glass product-contact surface protects against contamination.

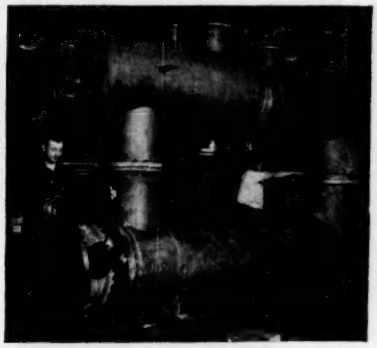
Your questions on applications, availability and other uses for Chemstor Tanks, complete with agitation, will be answered promptly. Send your questions to the address at the bottom of this page.

When your heat exchanger needs are very "special"...

Bring them to us. We may respond with an all-stainless unit like this one. It is an 840-square-ft. shell-and-tube exchanger with 30-inch-diameter shell, 16-feet long, for operation at 650°F, 75 psi. Tubes are made of type 316, and the shell is E.L.C., grade 304.

Or we might recommend components of titanium, zirconium, tantalum, Glasteel, nickel, Inconel, Monel, Hastelloy, or impervious graphite.

Since we fabricate, and are equally at home with the performance characteristics of all of these materials, you get the obvious benefit of an impartial design proposal. Often the answer to your special problems will be a *combination of* materials.



The intent is always to provide the optimum design in terms of heat transfer efficiency and corrosion resistance, at the *lowest* cost.

Tell us your problem. Or ask for Bulletin 949.

Please address all inquiries to our Pfaudler Division, Dept. CE-11, Rochester 3, N. Y.

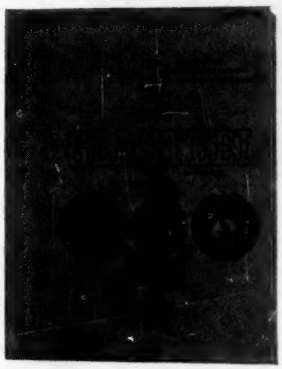
NEW BULLETIN—Glasteel, the Material of Construction

Just off the press is our four-color Bulletin 985, documenting the characteristics of Glasteel 59.

Of its 20 pages, 16 are devoted to *technical data* on specifications, thermal shock, operating temperatures, heat transfer, alkali resistance, acid resistance, and corrosion evaluation facilities.

This is the first time all pertinent data on Glasteel have been brought together in a single brochure. The results are impressive. Quite possibly this bulletin will suggest ways in which you can put this material of construction to use—reducing costs, improving service life of equipment, protecting product purity.

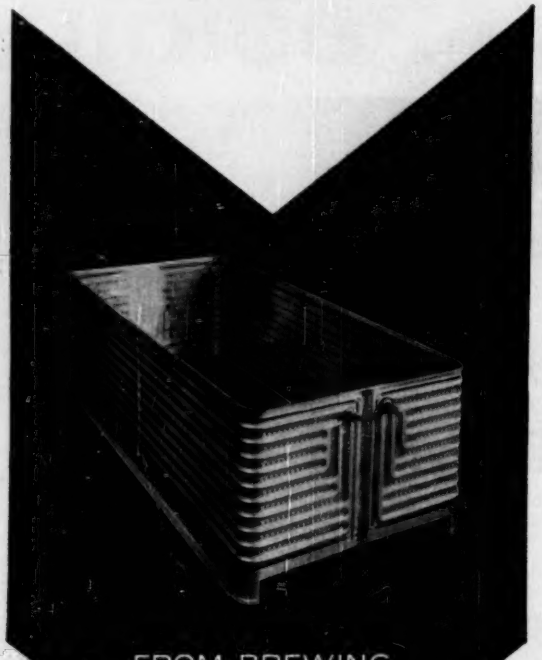
We think you'll find Bulletin 985 a worthwhile addition to your file. Write for your FREE copy.



*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes



PLATECOIL®

IS SOLVING MORE HEAT TRANSFER PROBLEMS THAN EVER BEFORE

New manufacturing techniques and facilities now make available a wider variety of shapes, forms and styles of TRANTER PLATECOIL—applicable to more tank and process heating and cooling and special heat transfer requirements than ever before.

A TRANTER PLATECOIL consists of two metal sheets, (one or both of which are embossed), spot welded and seam welded together to form channels for heating or cooling media. In addition to standard styles, PLATECOIL offers the design and development of specially formed PLATECOIL to meet specific application requirements.

Thousands of PLATECOIL applications to the heat transfer problems of the processing and manufacturing industries have saved users time and money on engineering, fabricating, installation and maintenance . . . out-performing other types of heat transfer equipment.

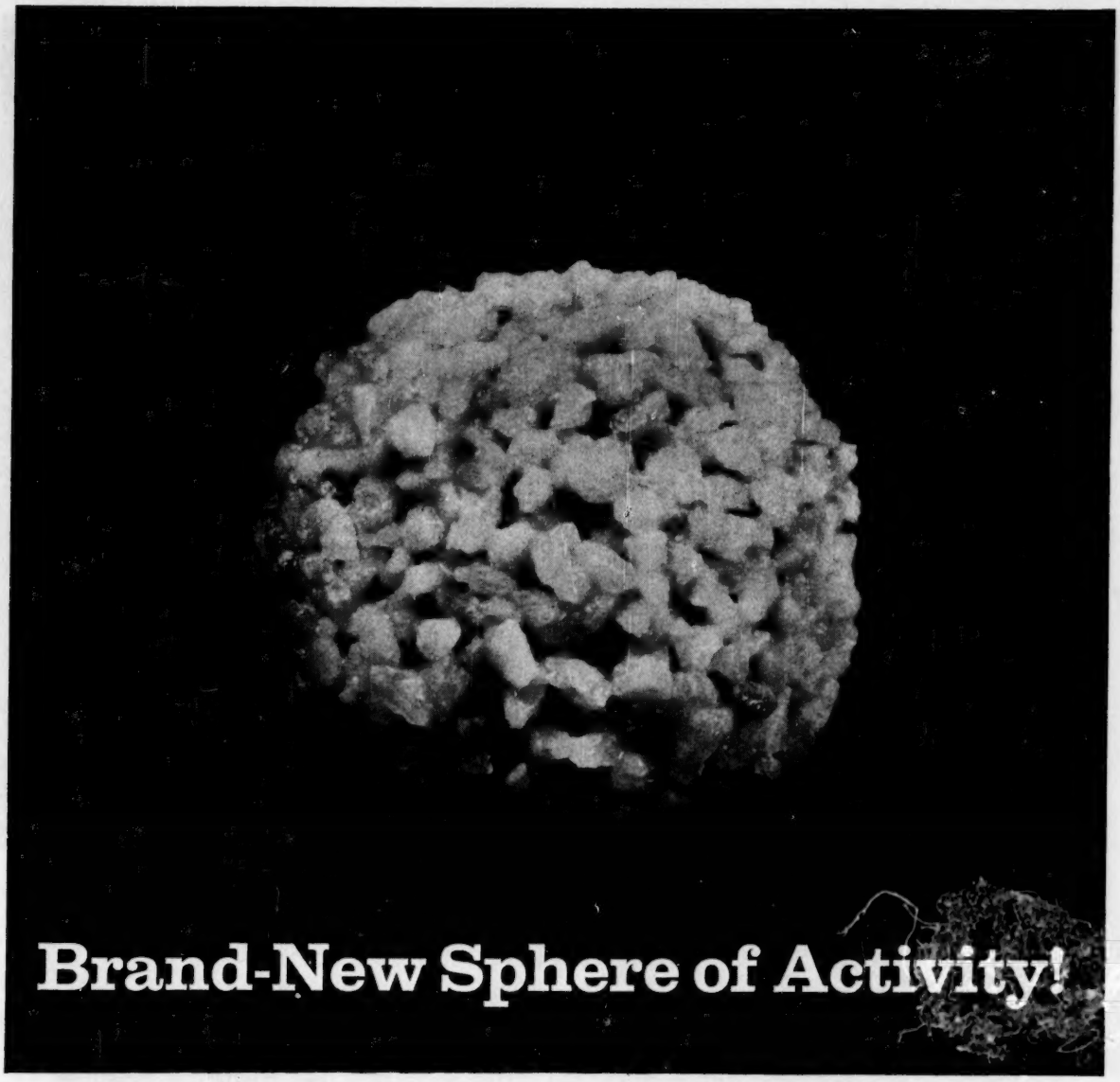
"Standard" Style 90 PLATECOIL with exclusive "MULTI-ZONE" design, for optimum steam distribution. Serpentine styles for cooling also available as standard.

Ask for PLATECOIL® BULLETIN P61.

Tranter Manufacturing, inc.

LANSING 9, MICHIGAN

PLATECOIL® DIVISION



Brand-New Sphere of Activity!

Here is a MACROPORT* "A" aluminum oxide sphere — Norton Company's newest development in catalyst carriers shown enlarged. Note its extremely porous structure, specifically designed to promote *faster, more precisely controlled* gaseous reactions. Pores are much larger than those in other Norton catalyst carriers, permitting gases to enter and diffuse readily, yet providing sufficient restriction for optimum control.

MACROPORT "A" catalyst carriers are currently available as spheres, pellets, and aggregate of fused aluminum oxide in the same price ranges as standard Norton carriers. A research program is now underway in the Norton laboratories to develop MACROPORT carriers in other materials.

For better yields from *your* reactors and improved process economy, get complete details on Norton MACROPORT "A" carriers. Write NORTON COMPANY, Refractories Division, 500 New Bond Street, Worcester 6, Massachusetts.

TYPICAL PHYSICAL PROPERTIES

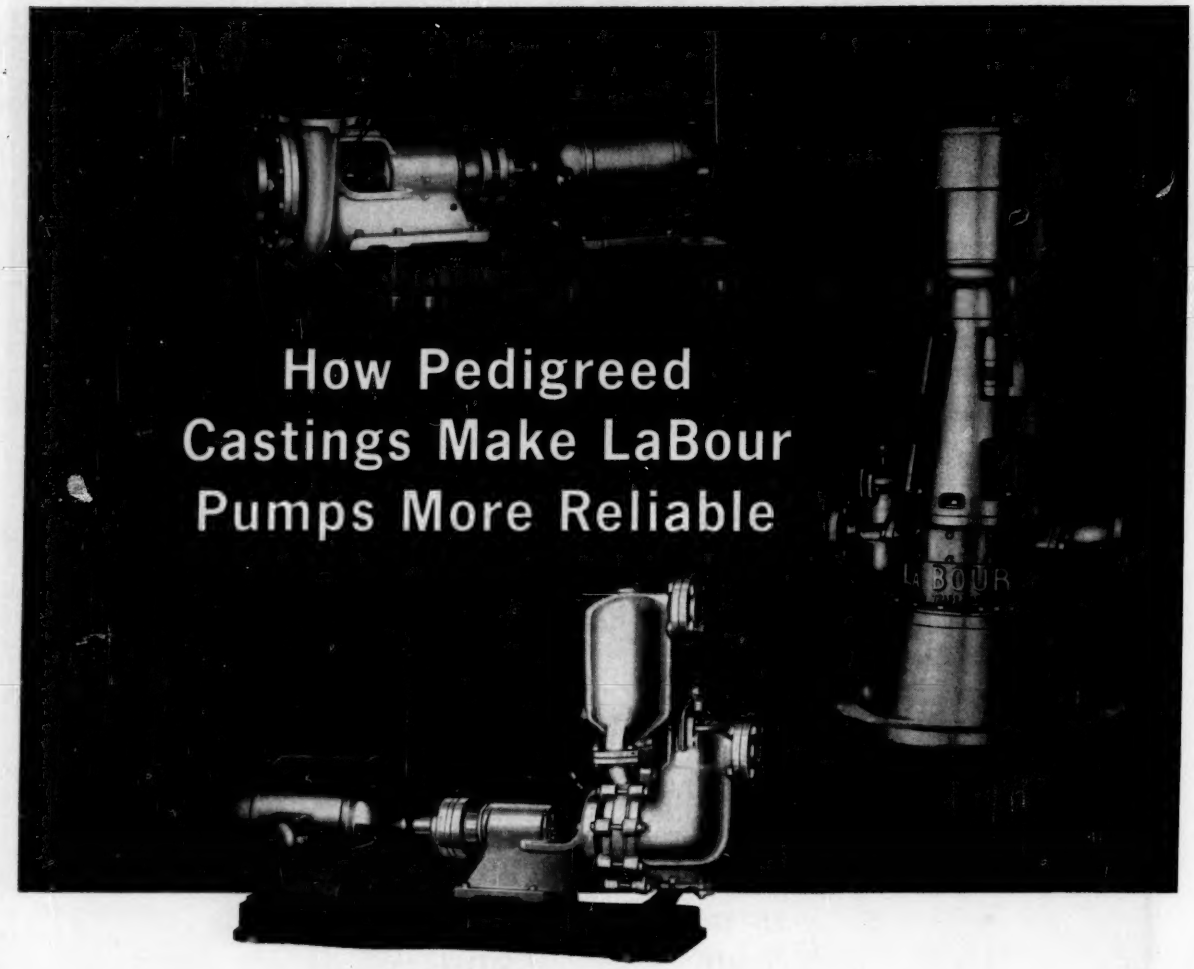
	MACROPORT "A" 5/16"-3/8" Spheres	Aggregate (3-5 Mesh)
Apparent Porosity %	44-48	40-44
H_2O Absorption %	22-26	18-22
App. Sp. Gravity g/cc	3.4-3.6	3.4-3.6
Bulk Density g/cc	1.8-2.0	2.0-2.2
Packing Density lbs./ft³	63-67	68-72
Pore Dia. Range	50-200 Microns	50-200 Microns

*Trademark

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

75 years of . . . Making better products . . . to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes



For nearly 30 years LaBour has carefully analyzed and recorded every heat of corrosion resistant alloys cast in its foundries and has permanently identified each casting with its heat.

Because LaBour knows the exact metallurgical structure of each individual casting, customers' requirements can be met with the greatest accuracy. Moveover, even small variations in analysis and casting conditions can be checked against field performance years later, so LaBour has acquired a wealth of information leading to improved alloys and foundry techniques.

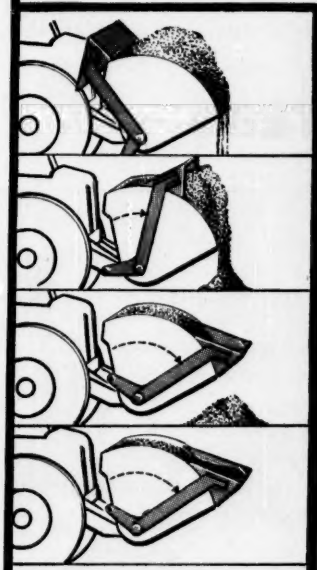
"Pedigreed" castings provide one of the many reasons why you can depend on LaBour pumps in all kinds of chemical service! Write for full information.

ORIGINAL MANUFACTURERS OF THE SELF PRIMING CENTRIFUGAL PUMP

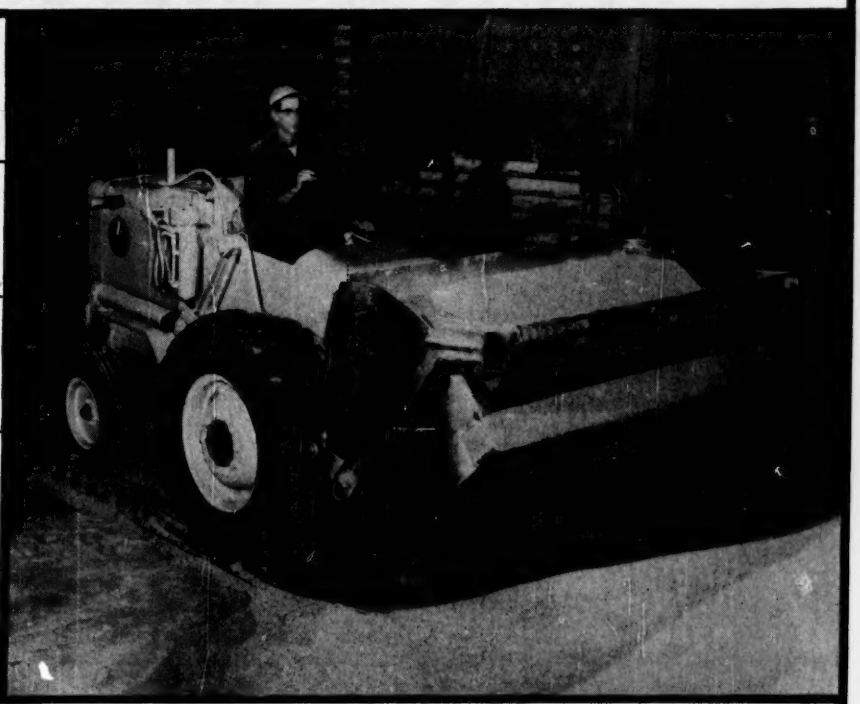
LABOUR

THE LaBOUR COMPANY, INC. • ELKHART, INDIANA
WHITE PIGEON, MICH. • LONDON, ENGLAND

New PAYLOADER® NO-SPILL Bucket



A strikerbar-spillguard blade, by hydraulic power, sweeps forward removing excess material. Blade remains forward in transport to retain load.



- Eliminates spillage during transport
- Saves costly floor and aisle clean-up
- Eliminates re-working spilled material
- Increases daily productive capacity
- Delivers uniform loads for "batching"

The "No-Spill" bucket is the latest of many PAYLOADER *firsts*, and makes the tractor-shovel a cleaner, more productive and more efficient materials mover than ever before. Its two features — the striking-off of excess material while loading, and preventing any loss of load while transporting — give many on-the-job savings and benefits:

1. Permits higher transport speeds for more trips and more production.
2. Delivers bigger loads as none is lost in transit.
3. Eliminates the dust nuisance caused by light, dry materials spilling in transit.
4. Prevents the accumulation and build-up of spillage along aisles — saves the cost and time of digging up and reprocessing such spillage.
5. Eliminates the contamination and waste involved when different materials are spilled on the same routes.

Three popular PAYLOADER sizes can be supplied with "No-Spill" buckets — the Models HA, H-25 and HAH. Your Hough Distributor will be happy to show you what they can do to improve materials moving efficiency on your operations. See him today or return the coupon.

HOUGH®

THE FRANK G. HOUGH CO.
LIBERTYVILLE, ILLINOIS
SUBSIDIARY — INTERNATIONAL HARVESTER COMPANY

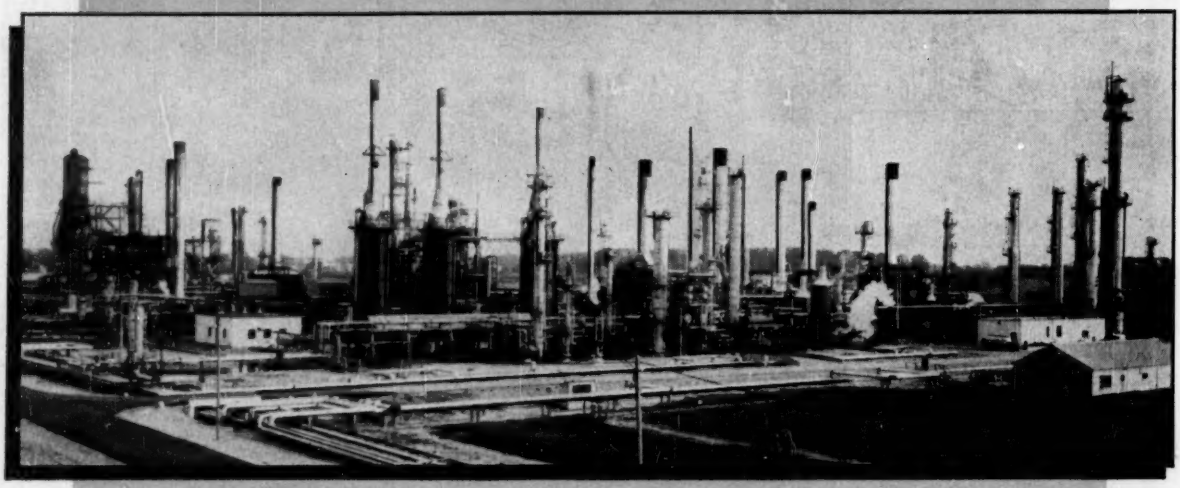
HOUGH, PAYLOADER, PAYMOVER, PAYLOGGER and PAY are registered trademark names of The Frank G. Hough Co., Libertyville, Ill.

THE FRANK G. HOUGH CO.
754 Sunnyside Ave., Libertyville, Ill.
Send information on "No-Spill" Buckets for PAYLOADER models.

Name _____
Title _____
Company _____
Street _____
City _____ State _____

1-A-1

HOW TO GET MORE OUTPUT FROM YOUR PRESENT PACKED TOWERS



General view of the Sarnia Refinery of Canadian Oil Companies, Limited.

Over the years, U. S. Stoneware, through its continuing research and development program on tower packings and packed tower internals, has gathered much valuable design data. Engineers from industries all over the world contact us regularly for help in designing units for extraction, distillation or gas scrubbing. Very often the problem is "How we can increase the output of a tower now in operation — and can we avoid a long shut-down period doing it?"

Take, for example, Canadian Oil Companies, Limited. Their Gerbitol units in Sarnia, Ontario, were packed with ceramic Raschig Rings. At their last "turn around," they replaced these with Polypropylene Plastic Pall Rings and changed the design of their support plate. As a result, their permissible DEA circulation in this liquid-liquid extraction column was doubled — and may yet be further increased. This was done, moreover, in just the time it takes to change packings.

If you have a problem involving mass transfer operations, pressure drop, capacity, theoretical plates, you'll do well to contact U. S. Stoneware, first.

PROCESS EQUIPMENT DIVISION

NEW ENGINEERING MANUAL ON TOWER INTERNALS

Just off the press, this new 32-page manual gives helpful data on how to select and install proper support plates, distributors and hold-down plates. For your free copy, write Dept. CEP-161.

U. S. STONEWARE

AKRON 9, OHIO

308-G

Top news stories and what they mean to CPI technical decision makers

Chementator

Air or oxygen? Ethylene oxide controversy crops up again

The battle between air and oxygen for the oxidation of ethylene to ethylene oxide is still simmering. Latest development: Union Carbide Chemicals, the U.S.'s ethylene oxide pioneer, will be experimenting with the oxygen-oxidation route at its existing EtO installation at Institute, W. Va. Carbide's Linde Div. is now building a tonnage O_2 facility at Institute to furnish the oxygen for the program.

The two licensers of ethylene oxide processes—Shell and Scientific Design—take opposing sides of the oxidation question. Shell's process is built around oxygen; Scientific Design recommends air. But Scientific Design says its process can be adapted to oxygen if the customer desires (see *Chem. Eng.*, July 28, 1958, pp. 100-103).

Union Carbide had long contended that oxygen offered few benefits. So its present move could signify a shift in ethylene oxide technology. But there is an additional factor that affects the economics in Carbide's case: it has a captive use for nitrogen at Institute, which helps pay off the oxygen plant. Carbide has already experimented with oxygen at its Texas City, Tex., plant, where it uses oxygen-enrichment of the air stream.

Mystery shrouds new organic fiber that withstands ultrahigh heat

An all-organic fiber that will not melt in a plasma jet at temperatures up to 18,000 F. is now being made in Minnesota Mining & Mfg. pilot plant.

Company identifies the fiber only as a compound of carbon, hydrogen, oxygen and nitrogen, free of elemental carbon. And it denies, in answer to *CE* question, that the fiber is a modification of polyacrylonitrile.

Though not made of graphite, the new material most resembles graphite fiber in high-temperature properties. However, it has higher tensile strength, does not conduct electricity. Other high-temperature fibers, glass and asbestos, melt at 1,400 and 2,000 F., respectively. Graphite and the new fiber never melt, though they eventually ablate.

Product is currently available in cloth form only, though 3M has plans to market the fiber form. No price has been made public to date on either product.

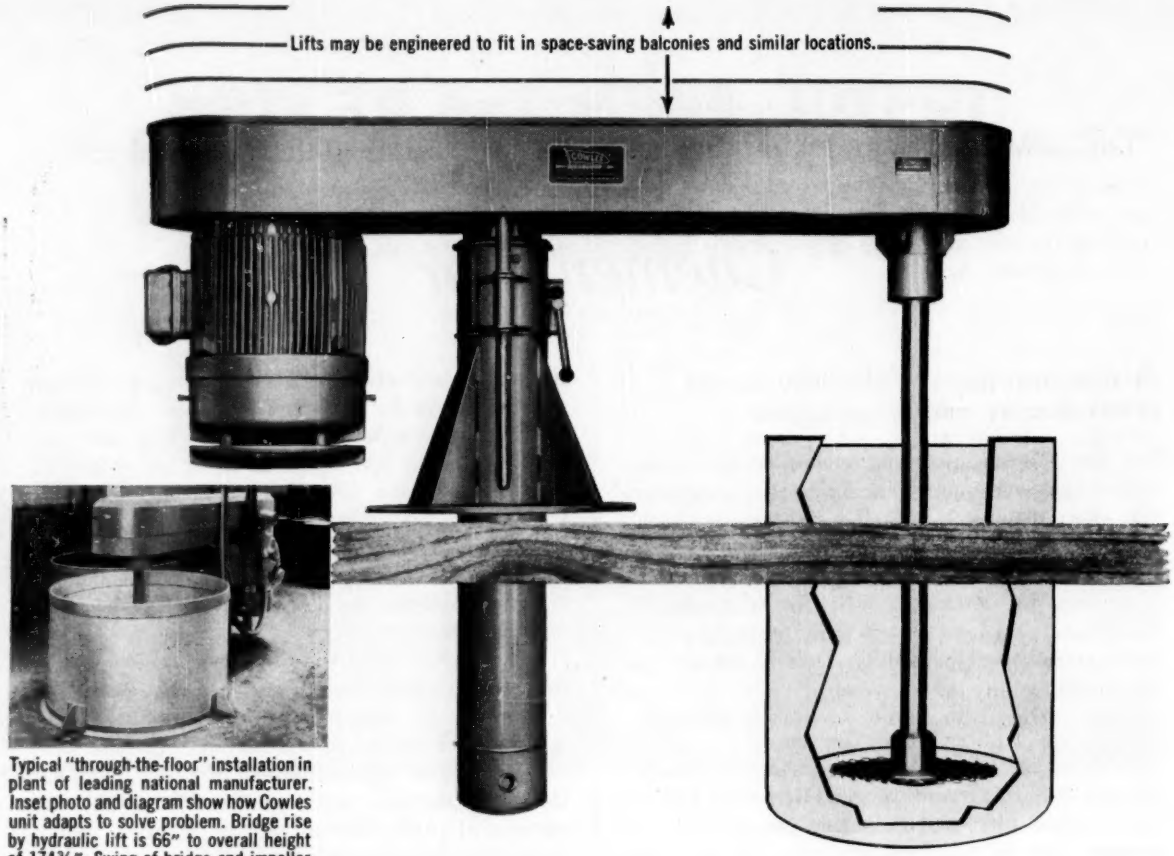
Potential uses for the fabric are missile motor-case liners, insulation for drag-chute compartments in high-speed jet aircraft, anti-arc wraps in electrical power plants. In the form of a laminate (approximately a 50-50 combination with phenolic resin) the fiber is suitable for structural parts, like missile nose cones, which must withstand intense heat.

Butyl lithium makers build plants to cash in on polyisoprene boom

Capacity for *n*-butyl lithium—on the market less than two years—will soon rise by 250,000 lb./yr., be readily expandable to twice that. Major commercial potential for the product is as a catalyst for polymerization of natural synthetic rubber (polyisoprene).

This month, Lithium Corp. of America starts up a second butyl lithium unit at Bessemer City, N. C., bringing its total capacity to 150,000 lb./yr. Foote Mineral has started construction of a 100,000-lb./yr. unit at New Johnsonville, Tenn., to augment existing semicommercial facilities. Also, American Potash & Chemical has a 75,000-lb./yr. plant in Los Angeles.

Shell Chemical, the only currently commercial polyisoprene producer, is said to be using the lithium catalyst. Firestone, too, is expected to use it for polymerization of both polyisoprene and polybutadiene in its upcoming plant. Extent of the new butyl lithium capacity seems to reflect optimism among producers that it will also be the catalyst choice of Goodyear, Goodrich-Gulf



Typical "through-the-floor" installation in plant of leading national manufacturer. Inset photo and diagram show how Cowles unit adapts to solve problem. Bridge rise by hydraulic lift is 66" to overall height of 174¾". Swing of bridge and impeller is 270°. One or multiple mixing tanks may be used — as batch or continuously. Available in 40 to 75 H.P. sizes with lifts engineered to meet plant requirements.

NEW COWLES *through-the-floor* DESIGN SOLVES MANY MIXING PROBLEMS

...in some cases may be the only solution!

Sometimes processing requirements, plant arrangements and space limitations seem to conspire against efficient, economical production. Originally designed to meet a special situation, this new Cowles model has been useful in so many cases of this kind that it is now in our regular line.

Where space can be made available on upper floors, balconies, walk-ways, etc., it may be the answer—*may even eliminate the need for major plant expansion!* It is applicable to fixed tanks as well as mobile —under certain conditions—for either continuous or batch operations.

The vertical set-up often saves vitally needed floor space. Gravity flow may be used to great advantage. Production can be piped direct to lower areas for further processing or packaging, since many products can be completed on the Cowles without the necessity for milling.

Separation of actual mixing from fume areas, reduced fire hazards and improved working conditions are important considerations in many instances.

All the advantages of Cowles Dissolvers are retained. Ultimate dispersion is attained in minimum space at minimum cost with the patented impeller "teeth that make the BIG difference." The exclusive MPD* (Maximum Power Delivery) transmission system delivers plenty of power even at slowest speeds. Cleaning between batches is simple and easy.

Your inquiry is invited. Write us today on your company letterhead. No obligation.

*TRADE MARK

MOREHOUSE COWLES

622 **MOREHOUSE-COWLES, Inc.**

1150 San Fernando Road, Los Angeles 65, Calif.

Representatives in principal cities • Convenient lease and time payment plans.

and American Rubber & Chemical, all of whom are building polyisoprene plants.

The lithium in the compound, like Ziegler-type systems (aluminum alkyl and titanium tetrachloride), is a highly directive isoprene polymerization catalyst whose product is high in cis-1,4 isomer, natural rubber's duplicate. In favor of the lithium compound: sold in solution in a liquid hydrocarbon such as heptane, it dissolves readily in isoprene monomer, and is used in such small quantities (0.1% of total raw materials) that its residual can be left in the end-product polymer without damage to properties.

Though researched for potential use in other stereospecific polymerization (e.g., propylene, styrene) lithium compounds appear most useful for isoprene. However, Firestone is reported planning to use it for polybutadiene as well.

Also, though *n*-butyl lithium is getting the emphasis at present, all producers make a point of stating that their capacity is flexible enough to produce any of a range of lithium alkyls. Many of the series are effective stereospecific catalysts.

A new fractionating column designed to distill viscous or high boiling materials will be designed, built and marketed by Vulcan-Cincinnati in conjunction with inventor E. C. Eckey. Unit has unique horizontal design, is said to operate with extremely low pressure drop and low energy input.

French isoprene process bids for worldwide commercial attention

Isoprene monomer, manufactured from isobutylene and formaldehyde, may soon graduate from pilot to semicommercial and commercial production. Developed by the Institut Francais du Petrole (*Chementator*, June 1, 1959, p. 35), the process has already been licensed to four firms: Cities Service and three Japanese companies. Three more contracts are to be signed shortly—one with a large French firm, another with a second U.S. concern.

Present U.S. isoprene plants, operating or under construction, make the monomer from isoamylene or propylene. Advantage of the IFP process is that feed hydrocarbon can contain as little as 10% isobutylene.

An existing French pilot plant with a capacity of 88 lb./day will be superseded this year with a 1-ton/day plant, to be set up by the French licensee with possible participation by the U.S. and Japanese licensees.

None of the known licensees has announced a full-scale commercialization of the process. The Japanese firms—Mitsubishi, Nippon Gas, Ube Kosan—must await government approval before going ahead. *CE* learned that approval may be granted next month to Mitsubishi, because of its leading position, and to Nippon Gas, which is more or less government controlled. Ube Kosan's position is uncertain.

Nuclear power for ramjet engines moved closer when the Tory II-A-1 reactor went critical for the first time at AEC's Nevada test site. Designed to fly only within the Earth's atmosphere, the nuclear ramjet would provide thrust by gulping in air, heating it in the reactor to a high temperature, discharging it at high velocity.

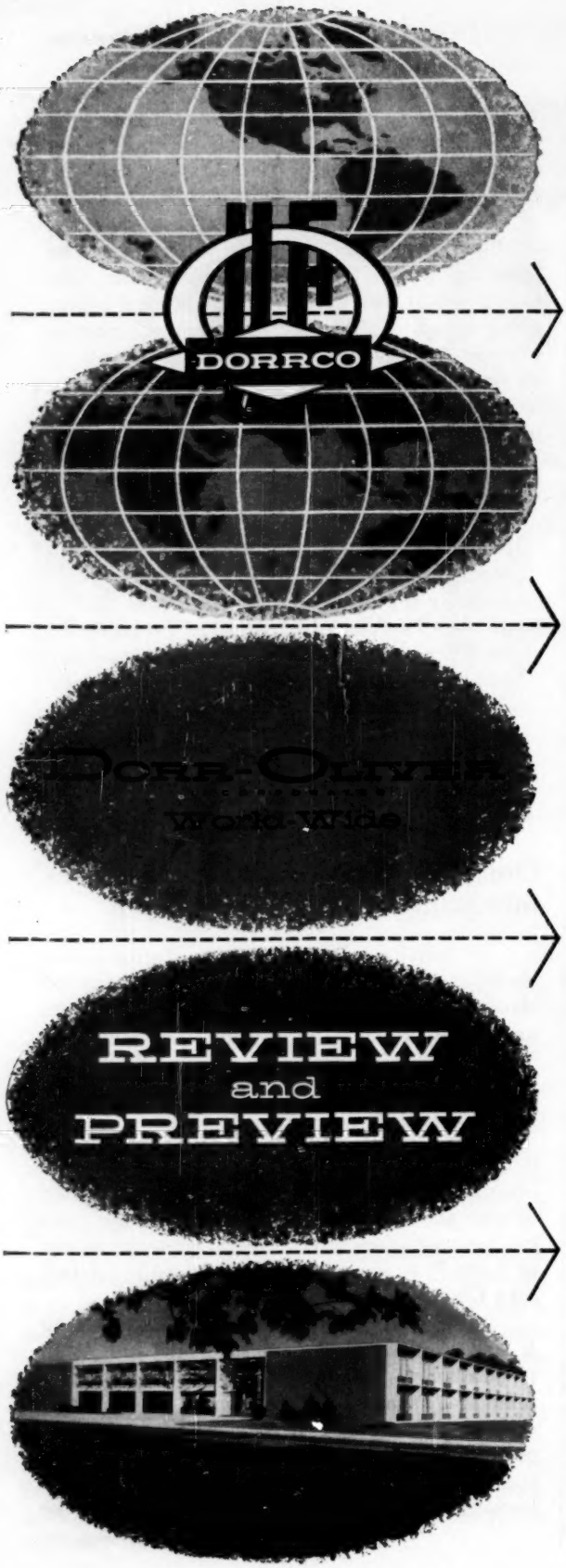
Doughnut-shaped coke furnace goes into semicommercial operation

A doughnut-shaped rotary furnace—the heart of a new coking process—is coming on stream at Dorchester, Va., to demonstrate its proficiency at coke production. Developed by Salem-Brosius Inc., Carnegie, Pa., and Whitney & Kammerer of New York, the process promises to be the first continuous route to coke.

The rotary furnace accepts coal feed, spreads it to a depth of about three inches during slow rotation, admits just enough air for combustion to heat the coking process, and discharges coke one to three hours later. Operating temperature of 2,400 F. is comparable to standard byproduct coke oven practice.

Located at a mine of the New York Mining & Mfg. Co., the semicommercial pilot unit is 10 ft. in diameter, or one seventh as large as contemplated commercial furnaces. Its capacity of about 16 tons/day of coke provides sufficient product for extensive evaluation of coke properties. The pilot operation will clear up one knotty problem—whether an auxiliary burner will be

(continued on page 38)



1960 has been a year of significant technical gain and measurable improvement in overall incoming business volume. In technology, a selective concentration of our development effort has begun to show results. Some of these new units and processes currently being marketed are mentioned below. Others, several of which show considerable commercial as well as technical promise, are nearing fruition and should be available during 1961. Progress in basic product standardization and redesign has also played a significant part in our technical advance and will have a substantial effect on our ability to serve our customers.

Virtually every segment of our worldwide operations has contributed to the increased volume of new business with an unusual degree of activity on exceptionally large projects apparent in many areas of the world. This overall gain has been reflected in somewhat higher billings and profits but a substantial increase in backlog has been the primary result.

METALLURGICAL—During the past year, the first installation of the new Dorr-Oliver DSM Heavy Media System went into operation on iron ore beneficiation in Minnesota. This process utilizes a DorrClone unit as the heavy media separatory vessel and other newly developed D-O units in the media cleaning circuit. As compared with conventional practice the new system provides better media cleaning, improved recovery and grade of ore and sharply reduces magnetite losses.

Included in the flowsheet is the D-O SiphonSizer, a hydraulic classifier operating on the hindered settling principle. In limited use for several years, this unit is now being applied in the metallurgical and non-metallics fields on both a commercial and experimental basis where sharper classification is of benefit.

For water conservation, one of the largest center pier Dorr Thickeners to be built in recent years is soon to go into operation for a major copper producer. Overall diameter of this unit is 375 feet.

NON-METALLICS—The continued installation of varied D-O equipment in wet process cement plants throughout the world has reflected the expansion of this industry, particularly in South America. It is interesting to note that in this latter area several Dorr Slurry Mixers in the 100 foot dia. range are being installed. These are among the largest ever fabricated.

A new development of significance in the cement industry was the introduction of the 270° DSM Screen —a unit which has increased grinding mill capacity when used for closed-circuiting or scalping. Considerable operating experience is available from several installations in Australia and Europe.

Substantial flowsheet improvement in phosphate rock beneficiation and coal washing has resulted from the application of sharper classification in Dorrco Hydroscillators and Sizers. The Oliver Horizontal Filter and the Dorrco FluoSolids System have been successfully operated in combination.

FOOD & PHARMACEUTICAL—In food and pharmaceutical industries, highly efficient separations coupled with economies in operating costs and space continue to attract processors to Dorr-Oliver centrifugal equipment. In the starch industry, for example, Merco Centrifuges, Mercone Screening Centrifuges and DorrClone Systems were selected in various combinations for expansions, modernizations and new plant facilities in Argentina, Mexico, the Philippines, South Africa, Uruguay and the United States.

Food processors also discovered the advantages of the DSM Screen and began to apply them to various dewatering jobs, such as germ separation, fibre washing and pulp removal from waste process waters. A new rotary vacuum filter of plastic construction, with interesting cost savings over stainless steel, performed well on clarification of fruit juices. Small diameter DorrClones in porcelain construction also solved speck and seed removal problems in various juice lines.

A leading manufacturer of new, high protein products for food and industrial use has utilized D-O equipment and services in developing new, continuous processes.

CHEMICAL—The versatile Oliver Horizontal Filter was applied to the washing and dewatering of a number of granular chemical products. A major breakthrough in the thermal drying of nitrocellulose by a special design of the Oliver Horizontal Filter resulted in substantial reduction in operating costs with a significant advance in safety. A multiple and repeat installation

of Horizontal Filters for phosphoric acid production was ordered late in 1960 from a major producer.

The newer unit operation of centrifugation continued to prove its potential in the field. Typical examples of its application are the successful use of Mercone and DorrClone units for carbon removal from paraffin oil and of a Merco Centrifuge for the removal of impurities from phosphorus.

PETROLEUM & PETROCHEMICALS—A new development of importance during 1960 was the application of the Mercone Centrifuge to the removal of liquids from polymer crumbs. One of the most exciting developments was the success of a special 'clamshell' DorrClone for catalyst removal from cat-cracker-fractionator bottoms. This solves a long standing refinery problem and should have wide application.

The Synrub filter is still an accepted standard in the processing of synthetic rubber both in the United States and elsewhere in the world. As an example, South America's first synthetic rubber plant, which was built during the year in Brazil employed a multiple D-O Synrub filter installation.

In the field of petroleum production, a principal D-O activity continued to be the use of DorrClone desanding and degritting units in water injection and drill mud conditioning. These are also now being applied to degritting of crudes.

The high demand for paraxylene has been partially solved by the application of a Merco Centrifuge separating paraxylene from a xylene stream at —80° F. Higher recoveries are achieved than ever before.

PULP & PAPER—The continuing increase in paper demand in every part of the world has resulted in the sale of brownstock washing, recausticizing and pulp bleaching systems both in the United States and abroad. Filters, pumps and sedimentation equipment have also been in demand for both pulp processing and such accessory services as water and waste treatment.

A significant advance in pulp bleaching by chlorine dioxide, the D-O concentric bleaching tower was made available broadly to the industry this year. The first of these towers has completed a year of highly successful operation in Idaho; the second will be in operation early this year.

Close cooperation and attention resulted in the supply of substantially all equipment for additional brownstock washing and bleaching sections at the newest mill in the Northwest.

MUNICIPAL AND INDUSTRIAL WASTE TREATMENT—Interest was extremely high in activated sludge treatment and applicable new D-O developments continued to gain momentum. The D-O Aerator was applied to the treatment of combined strong domestic and industrial wastes in municipal plants. Late in the year, the D-O Inka Aerator was introduced. Developed in Sweden and widely used in Europe, it combines high oxygen absorption rates with low power requirements and can be used most effectively on low BOD waste.

Programs conducted in the field on Densludge thickening and digestion were reported in detail during the year. One major city expects to save $6,000,000 in its current plant construction program through the use of this technique. In another interesting application, the Sultzer Disintegrator has improved digester performance in one large municipal plant when used to grind the thickened sludge.

Successful demonstrations of the RSR Clarifier proved the efficiency of this new unit for separating high volatile return sludge from waste sludge. Also, the use of the SpiroVortex System for the activated sludge process was further exemplified by a new installation in California.

In the area of sewage sludge dewatering, Dorr-Oliver Plastic Filters proved successful at Westport, Conn., and Paw Paw, Mich., while new filters of conventional design were installed at Harrisburg, Penna., and Marshall, Miss.

WATER TREATMENT—An outstanding event of the year in water treatment was the completion of the five-year construction program at Philadelphia's ultra-modern 423 mgd Torresdale plant for which D-O supplied four Dorrco Flocculators, and four Dorr Squarex Clarifiers. Another outstanding municipal water treatment plant is under construction by the Metropolitan Water District of Southern California. This plant will incorporate sixteen Dorr Squarex Clarifiers.

In the area of recent developments, a new Dorrco PeriFilter System will shortly go into operation at a southern city to treat 4.0 million gallons a day, and successful pilot plant demonstrations of an improved lime sludge handling method were carried out in several mid western cities. An increasing number of DorrClone units for desanding well water are being installed to protect meters and valves in industrial and municipal water supply systems.

Worldwide activity in new industrial plant construction, particularly in the pulp and paper field, has resulted in much activity in the application of both Hydro-Treators and conventional pre-treatment units to industrial water treatment.

PROJECT ENGINEERING — Much of the activity in this sector of D-O operations was provided by the rapidly expanding fertilizer industry. This included plants for the beneficiation of phosphate rock and for the production of phosphoric acid, ammonium phosphate, triple superphosphate and complete granular fertilizers. Typical of this area of activity are two phosphoric acid plants now being designed by D-O in Florida on a turnkey basis. A plant of unusual interest is being designed to recover ilmenite from heavy, mineral bearing sands for the ultimate production of titanium. D-O engineering includes the processing equipment, all auxiliary facilities and structures.

Other engineering projects include beneficiation of iron and copper ores, recovery of copper scrap, and facilities in such diverse fields as the pulp and paper industry, nitrocellulose manufacture, and starch production. Geographically, projects are underway in Africa, Brazil, England, France, Germany, India, Ireland, Japan, Jordan, Mexico and Yugoslavia as well as the United States.

FLUOSOLIDS SYSTEMS—1960 was a year of unusual activity involving both new and thoroughly demonstrated applications of fluid techniques. Plants for drying fine coal and both the drying and calcination of varied metallic and non-metallic ores continue to be in demand and contributed substantially to overall volume.

In the realm of the new and unusual—an important plastics plant went into production during the year utilizing a Dorrco FluoSolids System to dry the product Other similar applications are in the development stage. Another unusual application involving the roasting of copper concentrates for partial removal of sulphur prior to smelting will go into operation early in 1961. Also in 1960 a major chemical manufacturer ordered a third FluoSolids Reactor for processing food additives.

Of particular interest is a 200 ton per day lime plant scheduled for completion in mid 1961 in Florida. It is being completely designed and engineered by D-O on a turnkey basis with FluoSolids Reactors utilized in both the key steps of limestone drying and calcination.

SUGAR—Two new D-O developments were introduced to the Cane Sugar industry during 1960.

The D-O Rapi-Floc System introduces a controlled flocculation step before filtering of cane mud on a modified Oliver-Campbell Filter. The second development involved the application of DSM Screens to juice screening, with improved clarification and filtration reported as a result.

Throughout the year there has been a continuing demand for RapiDorr Clarifiers, Oliver-Campbell Filters and other standard Dorr-Oliver equipment for both new and expanded cane sugar mills, with the Middle East, Far East, Africa and Latin America particularly active.

We have several challenges ahead. We must provide our customers with even greater technical competence and service. We must continue to improve our profit structure to provide the income we need for continued technical and corporate growth in the future. We must provide growth and stability by adding to our product lines and areas of activity.

Through the dedicated efforts of our staff around the world we have made substantial progress in these areas during the past year. I am confident that this progress will continue and accelerate in the months ahead.

L. R. BOLING
President

December 1, 1960

needed to aid combustion of the fresh coal feed.

Salem-Brosius pointed out that the coke may not be a direct competitor with regular oven coke since its size will probably be under 1 in.; rather, it will be a chemical coke, suitable as fuel for a metallurgical sinter plant.

Advantages claimed for the new process over competing beehive and byproduct processes: low investment, good quality control, and low cost operation based on freedom from dependence on income from byproducts. Byproducts are not recovered in the projected commercial scheme, although they can be burned to provide part of the heat for the process.

World's first automatic electronic gasoline blender is on stream at the Wilshire Oil Co. of California refinery in Sante Fe Springs, Calif. Operator sets blend formulation by push buttons; when the desired quantity of blended gasoline is delivered, the unit will automatically shut off all valves, stop all pumps.

AEC opens door for U. S. firms to share gas centrifuge secrets

U.S. companies interested in developing gas centrifuges as a method of enriching natural uranium are breathing easier again—but only a little easier—upon AEC's announcement that private industry may be given access to classified secrets relating to the controversial equipment.

According to an AEC report, the firms would need security clearance, would have to prove that they were able and willing to undertake centrifuge research, and would have to make their results available to AEC. Publishing the report to get comments from interested companies, AEC did not indicate when, or even if, the change in policy would go into effect.

Just last summer, it asked Dutch and West German officials to clamp secrecy controls on centrifuge research. This incidentally tended to freeze out U.S. firms who were interested in obtaining foreign know-how or equipment (*Chementator*, Nov. 14, 1960, p. 106).

The commission's chairman, John A. McCone, said that a scientifically and industrially advanced country would probably require as many as eight years of intensive work to develop the gas centrifuge to the point where it could produce enough material for a nuclear weapon. AEC estimates that thousands of centrifuges would be needed to produce enough enriched uranium to make one atomic weapon per year.

For economical fuel-cell power, find a source of cheap sodium

M. W. Kellogg Co., New York, has just disclosed that it has been working with the U. S. Navy to develop a practical fuel-cell package, fueled with sodium and oxygen. And Kellogg has just landed a $764,000 contract from the Navy for a 100-hp. prototype power plant that could be used aboard ships.

Big advantage of the sodium cell: it has an open-circuit voltage of 2 v.—about double that of the conventional hydrogen-oxygen cell.

Including fuel, it weighs 2-3 lb./kwh. of capacity; can produce current densities up to 400 amp./sq. ft. at about 1.5 v. Normal operating temperature is 150-160 F.

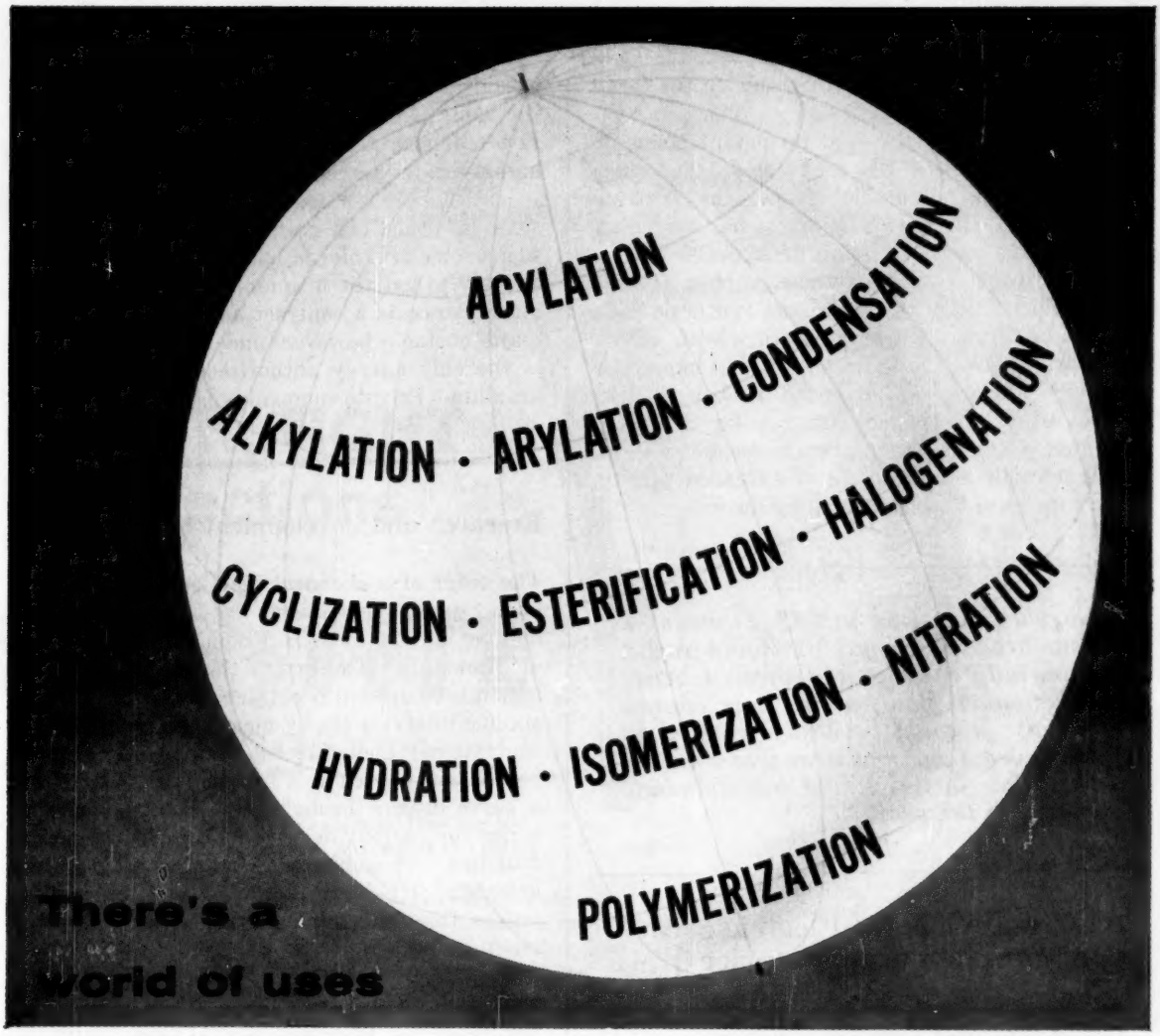
Main disadvantage of the system: cost of the sodium fuel. For the Navy's application, cost is not a factor, but for commercial application system's cost of about 20¢/kwh. puts it at a price disadvantage with units that use hydrogen or hydrocarbon fuels.

Key to safe handling of the sodium fuel is its introduction into the cell as an amalgam with mercury (½% Na). Amalgam runs down the anode in a thin film, reacting with the NaOH electrolyte to form sodium ions and electrons. Oxygen feeds into the hollow cathode to react with the electrolyte to form hydroxyl ions.

General tire finally wins patent on oil-extended tire-tread rubber

After a 10-yr. wait, during which oil-extended rubber has come from nowhere to account for half the SBR produced, General Tire & Rubber has been granted patent No. 2,964,083 for high-Mooney oil-extended rubber composition used for making tire treads.

At least 75% of the 700,000-odd long tons of oil-extended rubber produced in 1960 went into tire treads and is, therefore, covered by this patent. As soon as patent was granted, General sent out royalty application forms to 18 rubber producers, chose to file suit for infringement



for B&A® BORON TRIFLUORIDE

In the vast world of industrial chemistry, many organic synthesis reactions can be efficiently catalyzed by BF_3. What's more, this versatile catalyst will help cut production costs, increase yields and improve end products.

As America's leading producer of boron trifluoride, General Chemical has pioneered research and production of this "workhorse" catalyst. We were the first to introduce the concept of shipping BF_3 in complex form for ease in handling. Today our fleet of tank cars and tube trailers makes various complexes as well as the compressed gas immediately available in large commercial quantities.

For complete technical data on the properties and uses of these efficient catalysts, write for the free bulletins listed at right.

Title	Code No.
Boron Trifluoride, Compressed Gas	DA-34691
Boron Trifluoride, Compressed Gas Handling Information	TB-34691
Boron Trifluoride Dihydrate	DA-34671
Boron Fluoride Complexes with Nitrogenous Compounds	DA-3469-NIT-1
Boron Fluoride Complexes with Oxygen-Containing Compounds	DA-3469-OXY-1
Boron Trifluoride, Ether Complex, Tech	DA-34711
Boron Trifluoride, Monoethylamine Complex, Technical	DA-34661
Boron Trifluoride, Phenol Complex, Technical	DA-34681

BAKER & ADAMSON® Fine Chemicals

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

against only Goodyear and U.S. Rubber, for "procedural considerations."

General originally filed its patent claim in 1950; the invention was first allowed and then rejected as unpatentable. Now, the District Court of the District of Columbia has overruled the U.S. Patent Office Board of Appeals.

Technology of oil-extended rubber (*Chem. Eng.*, March 1952, p. 213) allows synthetic rubber to be diluted at the latex stage with an inexpensive petroleum-based oil, without impairing product quality. Oil-extended rubber is now about 5¼¢/lb. cheaper than regular SBR. A tougher polymer (of higher molecular weight than normal) is used in the oil-extended variety to compensate for plasticizing by the oil.

Corn Products, in first U. S. use of a new process, is making liquid sugar from milo grain at its Corpus Christi Bluebonnet plant, which was chosen because it could be easily adapted to the process and was near water transportation facilities and an abundant supply of the grain.

AEC and General Electric clash over enriched uranium price

Nuclear circles are anxiously watching for the next step in what promises to be some sophisticated haggling over the price of enriched uranium. The two adversaries: General Electric and the Atomic Energy Commission.

General Electric is now actively seeking bids on 1,000 tons of U_3O_8 yellow cake (total U.S. production of yellow cake is only 18,000 tons/yr.). GE believes that it should get yellow cake for around $5/lb., vs. the newly negotiated price of $8/lb. that the AEC will be paying to uranium mills after March 1962. Company's contention is borne out by Japan Atomic Corp.'s recently obtaining a price of $4.37/lb. in open bidding.

GE's move is designed to protest the AEC's present pricing policy for enriched uranium. General Electric says that the agency, which charges an annual use fee of 4% of the value of the uranium, bases the fee on yellow cake costing $12/lb. And this is out of line with the actual market situation, claims GE.

The AEC counters with the argument that its 4% fee is unrealistically low and is, in fact, a subsidy to the nuclear industry. If it adjusted the value of the uranium to the basis of a $5/lb. raw material, then it would have to charge a higher use-fee percentage, states the commission.

Although GE isn't revealing its strategy, some informed observers believe that it intends to get some firm bids in hand, then go to the AEC and try to get the uranium enriched in government plants as a contract service. There's one major obstacle, however: under present law, AEC is the only agency authorized to own enriched uranium. Private companies can only lease it.

Research and development briefs

The order of a chemical reaction can be simply and rapidly determined by a mathematical method devised by J. H. Flynn, National Bureau of Standards. The extent that an observed reaction is completed is obtained experimentally at specific intervals (as by measuring reactant concentrations) and different percentages of completion are plotted as a function of time. From a curve drawn through these points, values of times for various degrees of completion can be obtained and compared with time-ratio values calculated by Flynn for reactions of various orders, thus determining the related order of the reaction.

Thermally activated, a ceramic metal generator developed by Westinghouse operates with no temperature differential such as that required for thermoelectric or thermionic devices. An iron bar, successively coated with ordinary vitreous enamel and a thin silver layer, will give off up to 16 milliwatts/sq. in. of silvered surface when heated to between 200 and 750 C.

Optical masers that can continuously generate coherent light waves are under development by IBM. Such waves have a sharply defined frequency and propagate in a highly directional beam, suggesting applications in communications and other fields—including control of chemical reactions. IBM's masers use calcium fluoride crystals containing 0.1% uranium or samarium ions. Advantage claimed over previously announced ruby masers (*Chementator*, Oct. 31, 1960, p. 46): IBM's devices promise to generate continuous rather than intermittent waves, while operating with realistic power inputs.

For More Industry News . . . 42

Make QUICK, TIGHT connections with EVER-TITE Couplings

In every operation that calls for couplings, Ever-Tite will give you tighter, safer, connections—speed up changes and reduce "down time"—save leakage, maintenance and money.

Ever-Tite Couplings give a tight connection every time—under all conditions, for all flowable materials—because tightness is pre-determined and built in by compression on a resilient gasket*. And Ever-Tites are quick to connect—by just slipping the coupler over the adapter and closing the handles.

When you install Ever-Tites you get leak-proof connections between stationary equipment and portable equipment . . . utmost flexibility . . . quick interchange of couplings for experimental set-ups.

Available in Brass, Malleable, Stainless, Aluminum, Monel, or other materials for corrosion resistance under any atmospheric or operational conditions. In sizes, high and low temperatures, and pressure ratings to meet *your* needs.

Write today for illustrated catalog No. C-11.

*Ever-Tite gaskets are regularly supplied of Buna N composition. Also available in Neoprene, Pure Gum, Butyl, Silicone, Teflon, Thiokil, or any other material to meet specifications.

EVER-TITE COUPLING CO. INC., 254 WEST 54th STREET, NEW YORK 19, N. Y.

Install EVER-TITE Couplings on

- Loading equipment for tank cars, trucks, etc.
- Steam, air and water lines
- Pumps and other machinery
- Blending equipment
- Container filling devices
- Fire hydrants
- Acid handling at storage and transfer locations

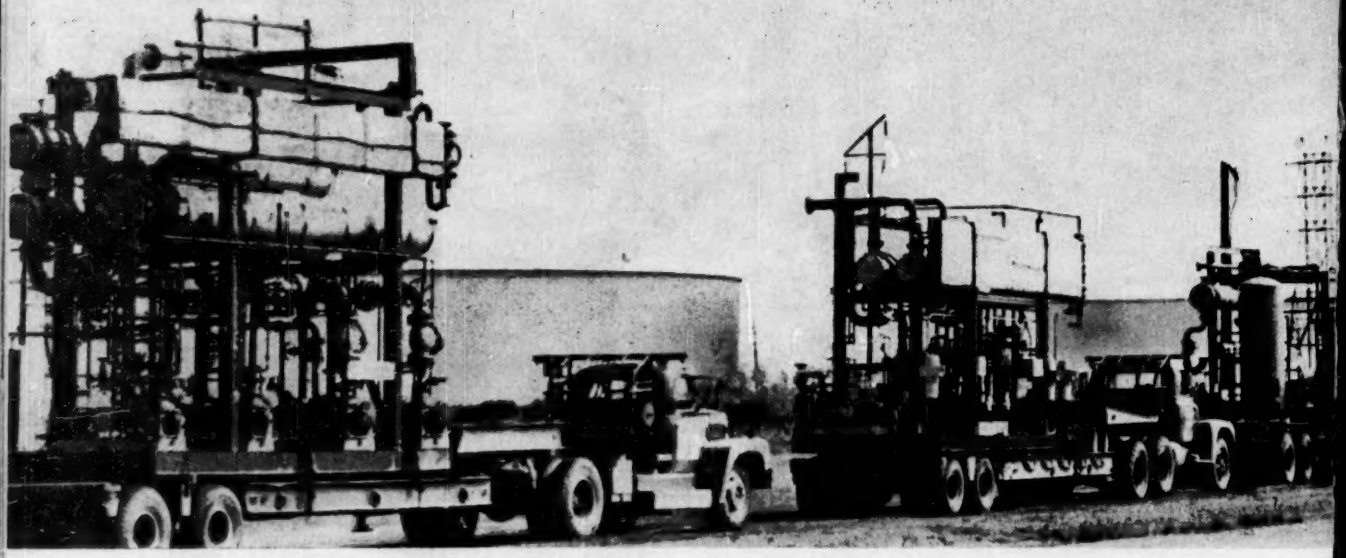
"If it calls for couplings it calls for EVER-TITE"

EVER-TITE Standard Adapter and Coupler

EVER-TITE Shank Hose Coupling

EVER-TITE Adapter and Coupler

EVER-TITE Adapter and Coupler for Tank Car Unloading



JUNGLE OIL REFINERY—MADE IN U.S.A.

By building skid-mounted units in the U. S., engineers bypass Guatemala's poor climate and lack of skilled labor to complete Central America's first oil refinery.

Advanced technology is out of place in the jungle. And yet—a 4,000-bpd. oil refinery will soon go on stream at Puerto Barrios, Guatemala, on a site that was completely covered with dense tropical trees and vegetation little more than one year ago.

Advanced technology found its place in the jungle, in this instance, because American engineers changed their design and construction tactics to fit an unusual set of circumstances.

When Lummus engineers conducted initial site surveys in Guatemala for Breaux Bridge Oil Refining Co., Inc., Houston, Tex., they discovered that the Guatemala labor market did not include the craftsmen needed to build a refinery. Furthermore, the country's 190-in./yr. rainfall threatened to seriously hamper construction activities.

▶Former Jobs Provided Know-How—Drawing on previous experience in building relatively small, skid-mounted portable process units, Lummus proceeded to design and construct the Puerto Barrios refinery in skid-mounted sections at its Houston shops, thereby overcame the handicaps that would be encountered at Puerto Barrios.

At the same time, some additional benefits accrued. Using skid-mounted procedures, Lummus could overlap design, procurement and construction schedules more than usual to obtain a shorter over-all schedule and lower cost. And skilled stateside craftsmen helped control construction procedures to a higher quality level than would have been possible with unskilled native labor.

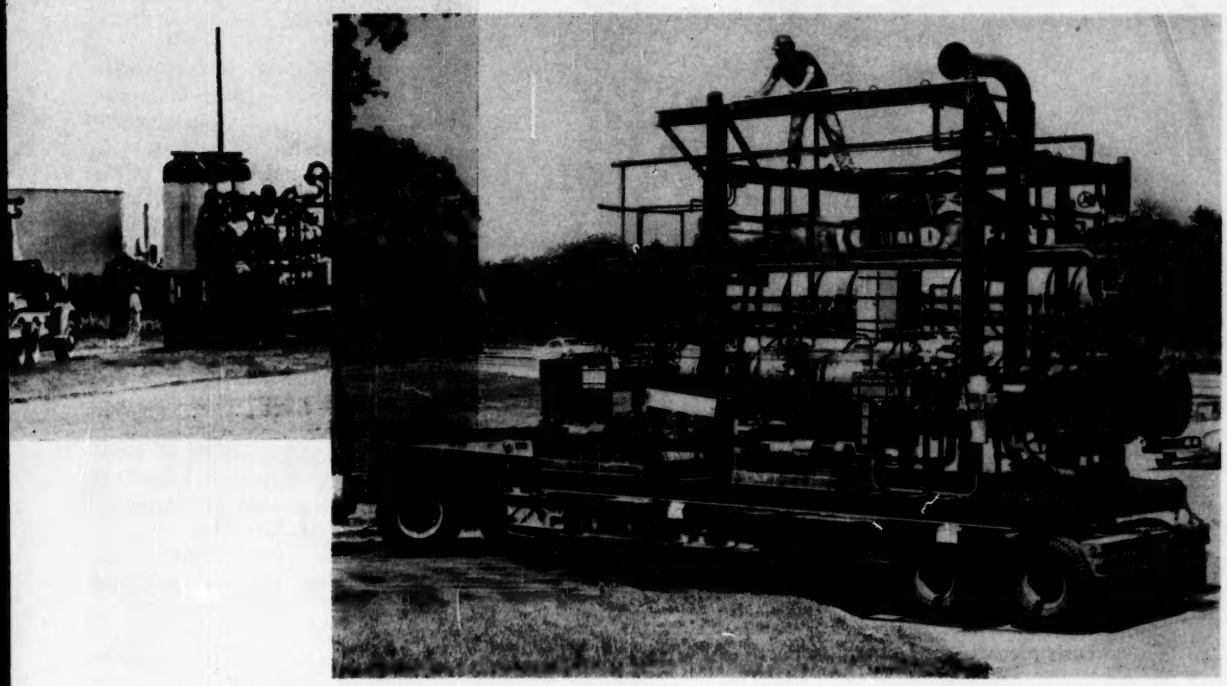
Flurry of Construction Activity on Gulf Coast

Emphasizing the growing importance of the Gulf Coast to the chemical processing industries, a flock of new projects are planned for the area. Among the most recent announcements:

Monochem, a joint venture of U. S. Rubber and Borden Chemical, has just taken an option on an 850-acre site in the Baton Rouge area. This is the firm's latest step in a plan to build a $50-million complex that will produce 150 million lb./yr. vinyl chloride monomer and 80 million lb./yr. acetylene. Natural gas will be supplied by Sugar Bowl Pipe Line Co.

Two hydrodealkylation plants, one to make naphthalene and one for benzene, are said to be on the drawing boards—but the two companies involved will not confirm at this time. Dow is reported ready to build a 30-million-gal./yr. benzene plant at Freeport, Tex., using Universal Oil Products' Hydeal process. And Monsanto is said to be getting ready to license Hydeal for a 50-million-lb./yr. naphthalene plant at Alvin, Tex. Monsanto would use this production in captive manufacture of phthalic anhydride.

A 50-mi. pipeline to bring "a



Assembled on skids at company's storage yard in Pasadena, Tex., 4,000 bbd./day refinery was trucked to Houston docks.

The Puerto Barrios refinery is the largest, yet most compact, skid-mounted unit ever built for processing crude oil. It includes a 4,000-bpd. crude unit followed by a 2,600-bpd. Unifiner, built under license from Union Oil Co. of Calif., and a 1,200-bpd. Catformer licensed from Englehard Industries.

All of the piping and equipment in the process units was designed to conform to the skid-mounted concept. A total of seven skids was required to hold pumps, reactors, compressors, exchangers, accumulators, etc. An additional five skids carried packaged equipment such as boilers, generators, furnaces, etc.

▶ **Tall Units Posed Big Problem**—The large fractionating towers could not be mounted on skids because of shipping limitations—50-ton crane limit on Guatemalan unloading dock; skid height held below deck-load limit to maintain ship stability. Prefabricated in the U. S., they are a 5½ x 60-ft. crude rerun tower, a 6 x 49-ft. crude fractionator, a 3½ x 38-ft. stabilizer on the Catformer.

Equipment is arranged on the processing skids so that pumps are on the bottom level. Exchangers, accumulators and vessels are on the second level, and the top or third level is used for pipe racks and interconnecting of skids. All valves, controls and instruments are located on the outside of the skidded units for easy operation and maintenance.

At the plant site, the process skids fit into an area 153 x 80 ft., out of a total refinery plot of 70 acres. Two 100,000-bbl. tanks will

---

substantial new supply" of natural gas to the Houston Ship Channel area will be built by Pan American Gas Co.

Advent of the new supply portends more chemical activity along the channel, most observers believe.

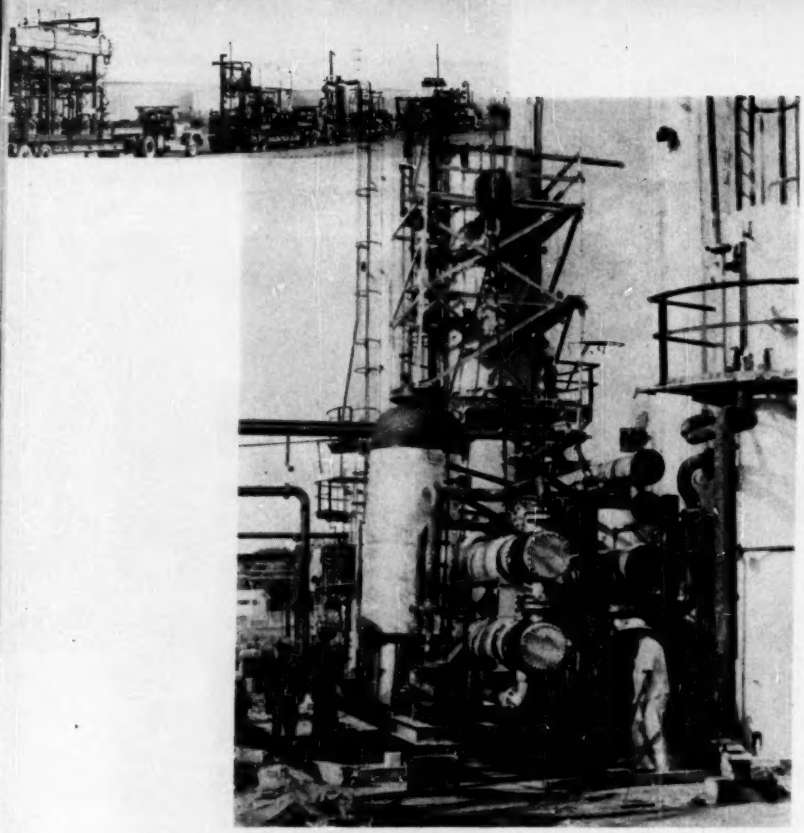
And Houston may be the starting point for a proposed 1,100-mi., 25,000-bbl./day propane pipeline that would extend through the southeastern propane markets.

Call Goes Out for New Fuels and Oxidizers

Solid rocket fuels with specific impulses close to 300 sec. have been predicted by L. G. Bonner of Hercules Powder at the recent meeting of the Manufacturing Chemists' Assn., in New York. But to achieve this, further improvements will have to be made in both fuels and oxidizers.

Powdered aluminum is already being used to give added zip to solid fuels. Interest is now being focused on lithium and beryllium, which might be incorporated into fuels either in the metallic or the hydride form.

In upgrading oxidizers, Bonner looks for a major effort aimed at producing stable NF_2-substituted compounds compatible with solid propellants.



At job site in Guatemala, skids were installed on previously prepared foundations.

store crude oil; storage tanks for various products total 125,000 bbl.

Refinery will be completely self-contained, with power plant, fire-fighting equipment, water and waste-disposal systems. Furnaces and heaters will burn refinery off-gases and fuel oil, while electric power will be supplied by two 300-kw. diesel-powered generators. Steam at 250 psig. comes from two 20,000-lb./hr. package boilers. Water from the nearby river will be treated by three different systems —for boilers, process cooling and drinking. Total makeup will be 250-300 gpm.

► **Centralized Control**—The entire process is monitored from one room, with a minimum of instruments mounted on units. By contrast with refineries of comparable size in the U. S., there is a greater number of scanning devices and warning alarms. The laboratory contains complete equipment for control testing, including octane test equipment and TEL blending facilities.

A first-aid station is in the same building as the control room and laboratory. Shops, warehouse and office will be in three separate structures. A complete supply of maintenance parts is stocked, since they cannot be purchased in Guatemala on short notice.

Radio will provide communication between refinery and the Guatemala City offices of the company. Plant operation, by 45-50 nationals, will be under the supervision of 11 Americans. In process operations, one American will supervise each shift of 2 Guatemalan operators. There will be three graduate engineers at the refinery —one American, two Guatemalans. —THA, CSC

Experts See Emphasis on Economical Space Fuels

As the civilian space program advances, propellants chosen for space vehicles will be different from those picked by the military. This is the opinion that A. L. Antonio, vice president of Aerojet-General Corp., expressed at the recent meeting of the Manufacturing Chemists' Assn. in New York. He sees a trend toward larger (and less expensive) propulsion systems for space exploration, rather than the high-density, high-impulse systems used in military rockets.

As an example, he notes that the liquid hydrogen-liquid fluorine combination has attracted military attention because of its density-impulse ratio. However, the cost of a liquid hydrogen-liquid fluorine system is $2.35/1,000 sec. specific impulse, while the older H_2-O_2 system costs only 28¢ for an equivalent amount of power. (Specific impulse difference of the two systems is small: H_2-O_2 is 390 sec. vs. 400 sec. for the H_2-F_2 combination.) The relatively minor difference in impulse, coupled with the big price advantage, makes the hydrogen-oxygen system preferable for space missions. Other attractive fuel systems for space: kerosene-oxygen and, hydrazine-UDMH with N_2O_4.

Another factor to consider in making market predictions for space fuels, Antonio notes, is that to achieve the 99%+ reliability required for civilian propulsion systems, a great number of preflight tests must be made. These tests usually consume as much as 200-250 times as much fuel as is required for a single launch, making the market for chemical propellants more attractive than would appear merely by calculating the number of space shots to be made.

Market for liquid hydrogen also stands to gain from NASA's interest in the nuclear rocket, which will use hydrogen as a working fluid. Liquid hydrogen requirements, for both chemical and nuclear rockets, are expected to reach 11,500 tons/yr. by '64. Estimated annual requirements for other chemicals by '65: 62,800 tons oxygen; 29,700 tons N_2O_4; 14,100 tons hydrazine-UDMH; 13,500 tons kerosene.

"Double-Seal"™

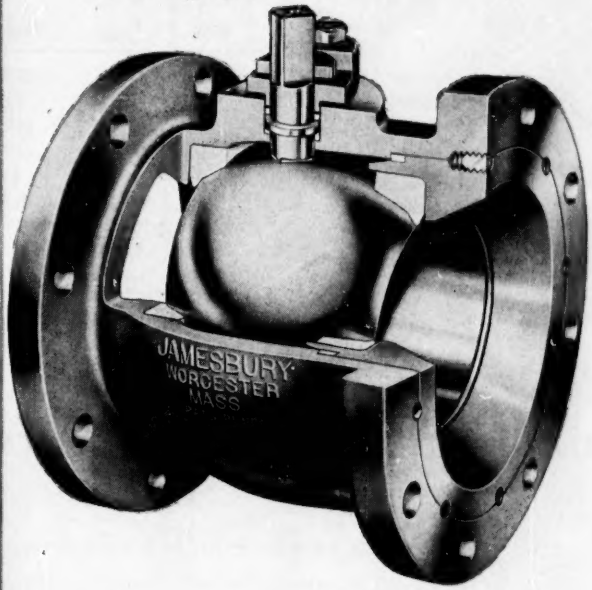
Outline for Successful Valving

jamesbury

BALL VALVES*

*PATENTED

"Double-Sure"



As Versatile As Industry Itself!

The words "Double-Seal" have delivered a new concept of valve dependability and performance. The exclusive "Double-Seal" design means complete shut-off on BOTH sealing surfaces of the ball. Because of this action the valve will hold pressure equally well in either direction.

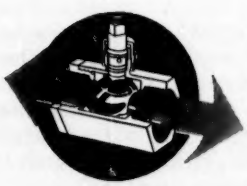
In long term high-cycling through a wide variety of applications, the "Double-Seal" Ball Valve has proven virtually maintenance free.

For maximum leak-proof performance, full flow and easy quarter turn operation, the Jamesbury "Double-Seal" Ball Valve is a proven leader.

Send for Jamesbury's "At Your Service" Literature

JAMESBURY CORP.,

62 NEW STREET, WORCESTER, MASS.



MATERIALS: **DISTRIBUTORS IN PRINCIPAL CITIES**

Jamesbury "Double-Seal" Ball Valves are available in Types 303, 316 and Alloy 20 Stainless Steels, Carbon Steel, Bronze, Ductile Iron, Monel, Aluminum and PVC. Other materials on special order.

Interchangeable seats and seals are available in "Teflon", Nylon, Buna-N, Neoprene, Hypalon and natural rubbers.

Pneumatic, Hydraulic and Electric Motor Operators to fit Remote Control Requirements.

SIZES:

Screwed End: ¼" through 3". **Flanged:** 150# series — ½" through 12". 300# series — ½" through 8"*.

*10" and 12" on application *600# series on application.

364-0 © 1961 Jamesbury Corp.

World aluminum consumption

Thousand short tons

	1958	1960	1965	1970
North America	1,558	2,210	3,275	4,365
Latin America	83	94	172	293
Common Market	482	560	819	1,257
Other Europe	399	481	657	854
Mid-East & Africa	28	29	40	55
Asia & Oceania	182	245	412	614
Free World	2,732	3,619	5,375	7,438
Soviet bloc	685	1,040	1,780	2,750
Total World	3,417	4,659	7,155	10,188

DECADE TO DOUBLE ALUMINUM USE

All overseas markets lack production capacity to meet aluminum demand so opportunities for new business in these geographic regions are exceptional.

In all parts of the world, prospects look bright for aluminum producers during the decade ahead. That's the gist of a recent survey* that summarizes the major world markets for aluminum and forecasts the consumption by regions.

▶ **Europe**—For the first half of 1960, U. S. exports of aluminum to Western Europe were at an all-time high, with the United Kingdom taking 63,000 tons, West Germany 47,000 tons, France 10,500 tons, and Yugoslavia 8,000 tons.

Seven of the 12 West European countries outside the European Common Market produce aluminum, with Norway accounting for about 45% of the total. Planned capacity for these countries will not cover the demand expected for the '60s, and in 1960 alone the area had a deficiency of 87,000 tons production compared with consumption.

▶ **Latin America**—The only aluminum produced in Latin America is in Brazil, where total production in '60 was an estimated 20,000 short tons, about 74,000 tons less than estimated '60 consumption for the area as a whole.

The immediate outlook is for a constant but relatively slow market growth. A 66,000-ton reduction plant is being built in Surinam, Dutch Guiana, and will be in operation in '64. But its production is slated for the ECM.

Brazil, Venezuela, Costa Rica and other countries have substantial amounts of undeveloped bauxite reserves. The Guianas have extensive deposits. A 245,000-ton alumina plant in British Guiana will start up soon.

▶ **Mid-East & Africa**—Because of political unrest and/or bare-subsistence economies, the Mid-East and Africa are more likely to remain producers rather than consumers of aluminum for some years to come. However, the Mid-East has no aluminum reduction facilities at present.

Africa's large deposits of bauxite, its great hydroelectric potential, and proximity to European markets, will contribute to its growth as a producing area. At present, the dark continent has only a single producer of primary aluminum, a reduction plant at Edea in the Cameroun Republic, which has an annual capacity of 50,000 tons.

Aluminum fabrication facilities in Africa are few and far between, scattered from the Republic of Congo to the Union of South Africa, with the bulk of them in the latter country. Combined capacity is about 12,000 tons of fabricated products annually, including sheet, extrusions, foil and wire.

▶ **Asia & Oceania**—Several countries of the Asia-Oceania area—most notably India and Australia—are increasing their productive capacity at a rapid pace and can be expected to lead in rate of growth in both the consumption and production of aluminum. Australia and Japan are expected to lead over-all economic growth rate and to assume the major role in Asian and world markets during the coming decade.

Japan is a major world producer of primary and secondary aluminum, despite high power costs, limited power resources and complete dependence on imported bauxite. Future gains in primary production will be limited by power capacity and the industry's ability to expand fast enough to match a rapid growth in consumption.

Australia imported all of the aluminum it consumed until '55, when the 14,000-ton Bell Bay reduction plant went into operation on the island of Tasmania. Aluminum consumption, still low, tripled between '50 and '58, most of it going into construction and equipment. Australia's reserves of bauxite are among the most extensive in the world, with deposits in Tasmania, Victoria, New South Wales and the Northern Territory.

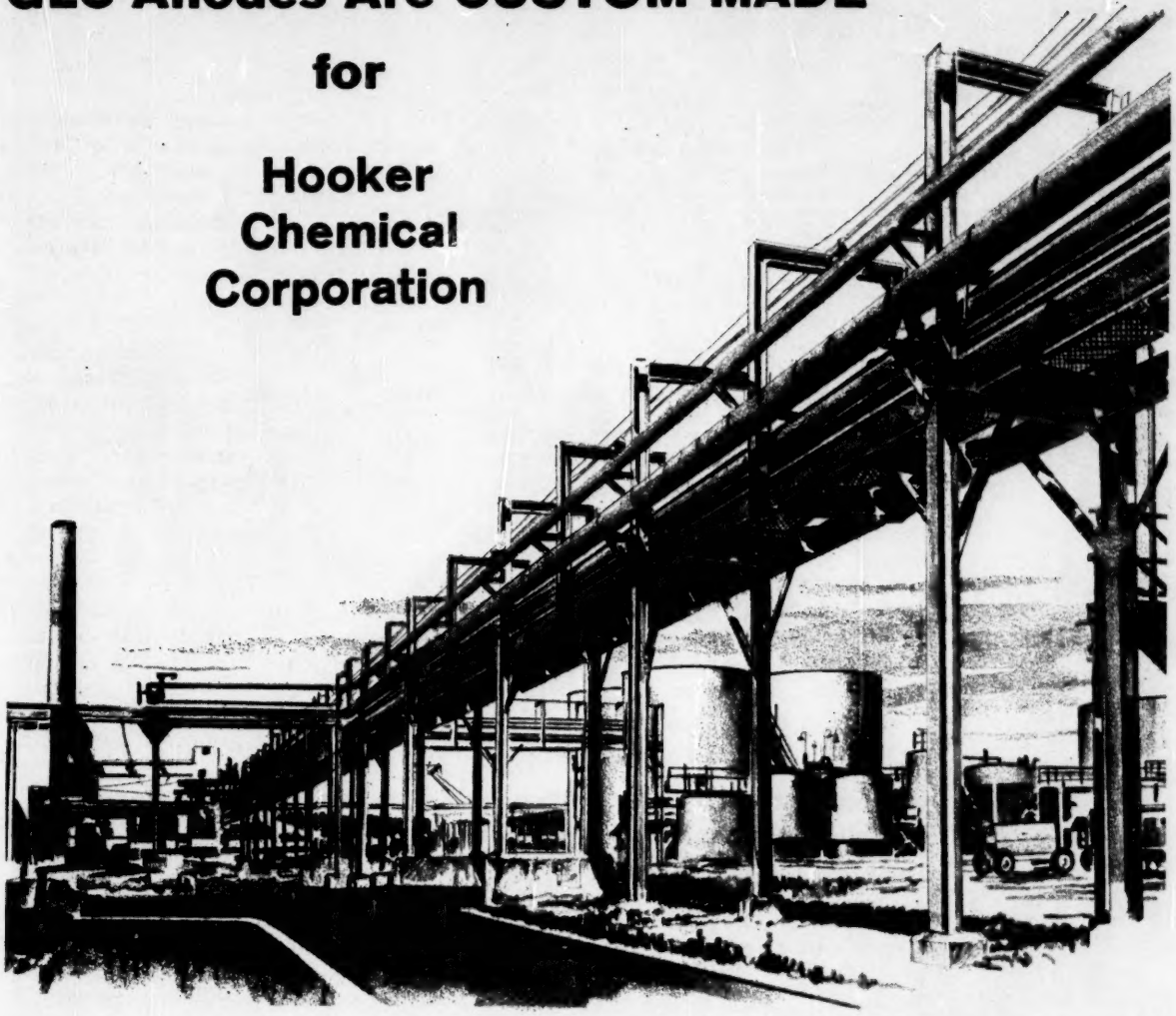
Several factors favor a large expansion of the Indian aluminum industry in the next decade. These include extensive bauxite deposits, absence of major deposits of other nonferrous metals, large aluminum conductor demand for increasing power distribution, and a gradual but definite shift from household uses to industrial applications.

* Conducted by Kaiser Aluminum & Chemical Co. and reported in current issue of *Kaiser Aluminum News*.

GLC Anodes Are CUSTOM MADE

for

Hooker Chemical Corporation



The Hooker Chlor-Alkali Plant at Montague, Mich.

Longer anode life, longer diaphragm life, reduced power consumption and reduced labor costs are the goals of the GLC program of technical exchanges between our engineers and those of our chlor-alkali customers.

GLC anodes now in use are achieving greater records of performance than ever before.

And as a result of our continuing technical exchange program, GLC customers can look forward to still better anode performance in the future.

Are your chlor-alkali operations experiencing the cost-saving advantages of GLC anodes, custom made to your special requirements?

PRODUCTS ELECTRODE GLC DIVISION YOU CAN TRUST ®

GREAT LAKES CARBON CORPORATION

18 EAST 48TH STREET, NEW YORK 17, N.Y. OFFICES IN PRINCIPAL CITIES

Operating rates

	Preferred	Spring 1960	Current
Chemicals & allied products	93%	82%	77%
Petroleum refining	97	86	83
Pulp & paper	100	91	90
Rubber	96	84	85
Stone, clay & glass	90	78	76

Capital spending (million dollars)

	Record Year: 1957	1958	1959	Est. 1960	Projected Last Spring: 1961	Current Projection: 1961	Planned: 1962
Chemicals & allied products	1,724	1,320	1,235	1,610	1,721	1,640	1,593
Petroleum refining	853	665	583	711	826	803	803
Pulp & paper	811	578	630	750	678	690	528
Rubber	200	134	190	240	245	230	198
Stone, clay & glass	572	399	529	630	585	560	554
All CPI	4,160	3,096	3,167	3,941	4,055	3,923	3,676

CHEMICAL SPENDING: CLIPPED BUT . . . . . STILL GROWING

Slightly depressed since spring by slipping profit margins and low operating rates, capital expenditures planned by the chemical industry for 1961 remain 2% greater than near-record 1960 expenditures

ALFRED LITWAK,
McGraw-Hill Dept. of Economics

Chemicals producers and petroleum refiners will break step with other chemical process industries to increase their capital expenditures in 1961. Both these key CPI groups plan to spend more for new plants and equipment in '61 than in '60, the McGraw-Hill fall survey of business' preliminary capital-spending plans reveals. And while firms in rubber, paper and pulp, and stone, clay and glass manufacture now plan reductions in their capital outlays, planned CPI spending in aggregate is within a fraction of '60's total.

In the chemical industry, spending for '61 is now pegged at a modest 2% higher than in '60. Outlays for new plants and equipment will come to $1.6 billion. And chemical companies already have plans to spend almost as much in '62.

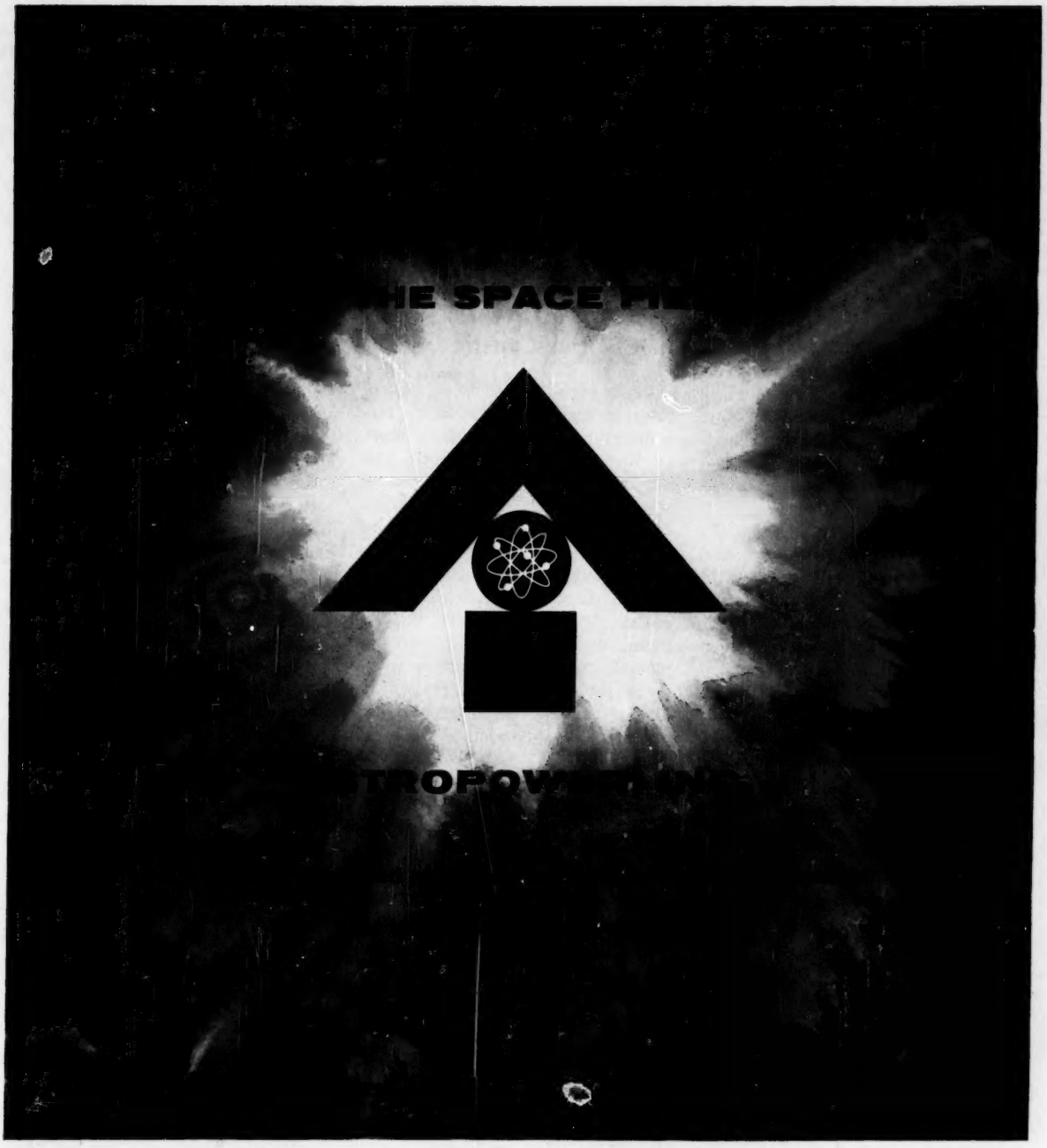
Petroleum refiners predict a far greater increase in outlays. From an estimated $711 million in '60, plant and equipment expenditures in this industry are expected to rise to $803 million in '61. This represents a 13% increase. And refiners are set to spend the same amount in '62.

Rubber producers, on the other hand, may cut back slightly. Projections for '61 are 4% less than in '60. Capital expenditures in the paper and pulp industry are now slated to drop 8%. Stone, clay and glass manufacturers will make the process industries' sharpest reductions in '61, aim to cut plant and equipment expenditures by 11%.

Spending plans of chemical process firms, and of manufacturers generally, reflect reductions in industrial activity and operating rates that occurred during '60. Firms in every manufacturing industry are operating substantially below their preferred output level. Their need for new capacity therefore is not pressing.

In the McGraw-Hill survey conducted in October, manufacturers reported that only 79% of productive capacity was being utilized. Earlier in the year, however, they set preferred operating rate at 94% of capacity. When the fall survey was taken, the chemical industry reported 77% of its capacity in operation. Its preferred operating rate is 93%. Rubber producers, who prefer to operate 96% of their facilities, were using only 85% this fall. However, unlike manufacturers generally, they were operating a greater proportion of their productive capacity than in December '59.

Capital spending for '60 will not achieve the level planned earlier in the year. Undoubtedly, the decline in operating rates throughout industry weighed considerably in



Astropower, Inc. has been formed as a subsidiary of Douglas Aircraft Company with Mr. Y. C. Lee, internationally noted propulsion expert, as president.

In offering its services for research and development of advanced space propulsion systems to system contractors and government agencies, Astropower will operate as an independent company. The proprietary interests of major systems and sub-systems contractors will be respected and protected by both Douglas and Astropower.

A balanced engineering and research program is now being formulated to advance the state of the art in—

- Ultra-high energy propulsion systems in the nuclear, chemical and electrical fields
- Solid state devices and energy conversion equipment

Mr. Lee is now staffing key positions in Astropower, Inc. and will welcome inquiries from qualified engineers and scientists having advanced degrees in the areas of nuclear physics, plasma physics, solid state physics, thermodynamics and high temperature materials.

Astropower's permanent scientific and engineering center will be located in one of Southern California's ideally situated research communities.

ASTROPOWER, INC.

Temporary headquarters: 3801 Lakewood Boulevard, Long Beach, California

manufacturers' decisions to hold back on some outlays originally scheduled. Last spring, when McGraw-Hill conducted its 13th annual survey of business capital spending (*Chem. Eng.*, June 13, 1960, p. 90), manufacturers slated $15.2 billion for new plants and equipment during 1960. Actual expenditures will come to $14.3 billion. In each of the CPI industries, outlays for '60 were trimmed below originally planned levels.

CPI planned spending conforms to the general pattern revealed by the survey. For manufacturing, and for business as a whole, outlays for '61 are 3% lower than last year's expenditures, with some industries planning increases, while others foresee reductions. A decline of this dimension is modest indeed, compared with that of '58.

The results of the fall survey carry special importance for business and the U.S. economy generally, because they indicate that capital investment will be sustaining the nation's economic activity in '61. Despite slipping profit margins and a level of operations that leaves considerable producing capacity unused, business firms now plan a volume of spending that eliminates concern over a major business slowdown in '61.

And plans are based on expectations of only modest improvement in manufacturers' business. Sales, on the average, are expected to increase by only 3%.

Paper and pulp producers are among the most optimistic in predicting '61 sales gains, expect a 5% increase. The chemical industry is counting on a 3% gain, as are petroleum refiners and rubber producers. Makers of stone, clay and glass products, on the other hand, expect no change in volume, thus no significant improvement in their operating rates. And this may account for the sharp reduction indicated in their '61 plans.

Results of this survey suggest that CPI, and other manufacturers are going ahead with the task of modernizing their producing facilities. Last spring, they indicated that nearly two thirds of '60's planned capital expenditures would be for replacement and modernization of obsolete facilities. With operating rates relatively low, efficient plants and equipment are important bulwarks of profit margins. Modernization and replacement thus are encouraging plans for another year of substantial outlays.

New World Records In Chlorine-Caustic

World productive capacities of chlorine and caustic soda by economic regions were broken down by Bert Cremers, Wyandotte vice president, at a recent meeting of the French group, Societe de Chemie Industrielle.

World production of chlorine in 1959 reached a new record of 8.1-million short tons with plants operating at approximately 82% of installed capacity. This record was made in 417 units operating in 55 countries. Caustic soda production also set a new record in '59, with total world production at 11.4-million short tons or 79% of installed capacity. There were 460 caustic plants operating in 56 countries.

North America has 61 chlorine producers with a capacity of 5.528 million tons and 61 caustic soda producers with a capability of 6.520 million ton/yr. It's in first place by a wide margin over any other economic bloc in the world, has twice as much chlorine capacity as the rest of the world combined.

The new European economic community has 67 chlorine plants totaling 1.709 million tons and 70 caustic plants totaling 2.572 million tons. The European free trade area has 29 chlorine producers accounting for 921,000 tons and 29 caustic producers, for 1.365 million tons.

The Soviet bloc, on the basis of obtainable data, has 30 chlorine manufacturers producing 697,000 tons and 36 caustic producers making 1.633 million tons.

Asia and the South Pacific have 64 chlorine producers (648,000 tons) and 88 caustic producers (1.767 million tons).

Central and South America have 43 chlorine producers (153,000 tons, 45 caustic (255,000).

Africa has 10 chlorine plants (34,000 tons), 10 caustic (35,000 tons).

Rapid growth of chlorine demand has had a profound effect on caustic soda production. In '59, on the entire North American continent, less than 10% of the caustic produced was made by the lime-soda operation. In the entire world, in '50, approximately 50% of caustic soda was made this way. By '59, it was 33%, indicating worldwide shift to the electrolytic process.

The total world investment in chlorine facilities on a replacement basis in terms of dollars would be about $2.7 billion.

Accurate worldwide end-use patterns are not available. But the U.S. chlorine pattern is: 81% chemical; 15.5% pulp and paper; 3.2% sanitation; 2% miscellaneous. For caustic soda: 32.4% chemicals; 15% rayon and film; 11.4% pulp and paper; 6% soap and cleansers; 5.4% petroleum refining; 5.4% textiles; 5.3% export; all other, 19.2%.

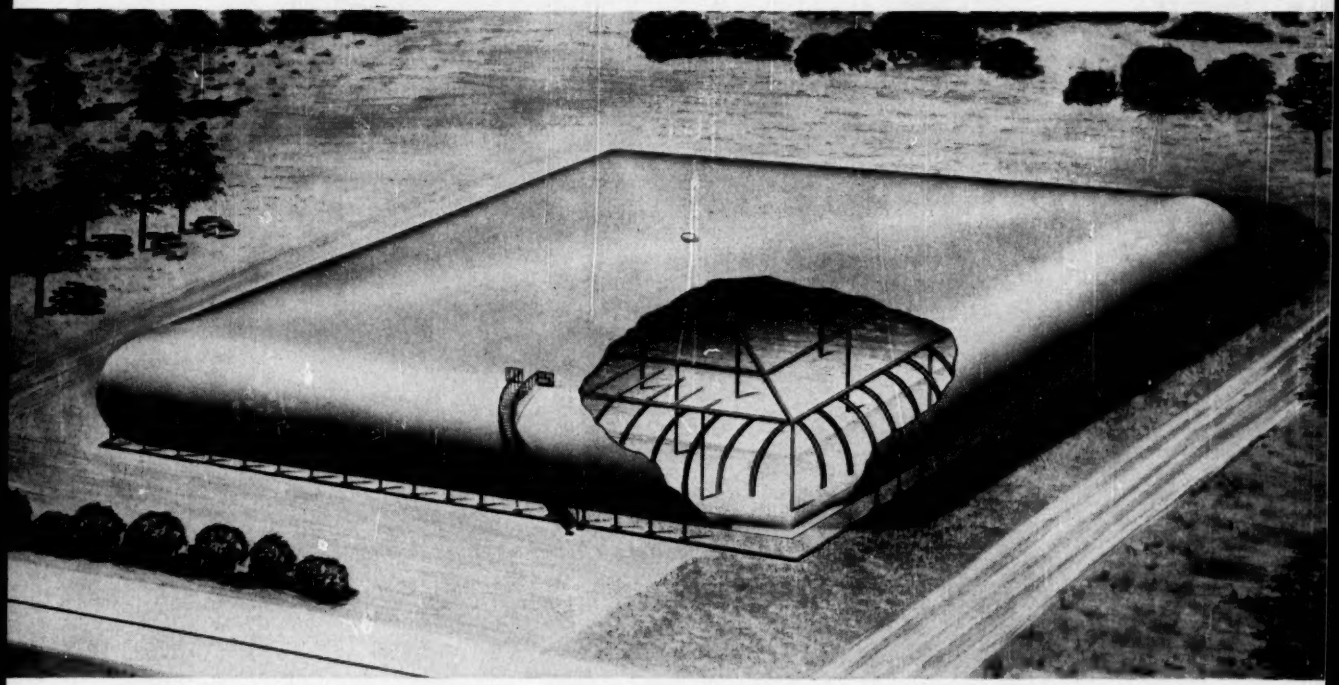
Hydrogen Still Looks Best for Fuel Cells

Hydrogen is now the best energy source for fuel cells, but it and other fuels fall considerably short of the "ideal." This is the opinion voiced by G. E. Evans of Union Carbide Products Co. at the Washington meeting of the American Institute of Chemical Engineers.

Evans' five requirements for an ideal fuel: high available energy per unit of weight or volume, safe and convenient handling, ability to deliver high power rates, stability and noncorrosiveness, and low cost. Hydrogen is most widely employed because of the simplicity of the hydrogen oxidation reaction. But its energy content per unit volume is low and cost of shipping is high.

Advances in liquid hydrogen technology and the use of metal hydrides may improve the economics of the hydrogen-oxygen cell. Cheaper fuels such as methane, propane, gasoline or fuel oil would be more desirable, but no one has demonstrated a practical fuel cell using these materials, declares Evans.

A High-Efficiency Housing Development for the Petroleum and Chemical People... the Graver Cylindroid



This major breakthrough in storage facilities is a functionally-designed, rectangular tank that can be built to fit available land . . . it has been thoroughly tested as a full-scale, field-erected tank.

Stores u, , more than a cylindrical tank of the same dimensions . . . can be designed for any capacity, and offers greater capacity with lower cost-per-barrel storage . . . this is the new Graver Cylindroid.

For petroleum products and chemicals—for just about any liquid—the Cylindroid is highly efficient and economical for large-volume storage.

Write us to learn what the Cylindroid can do for your storage problems.

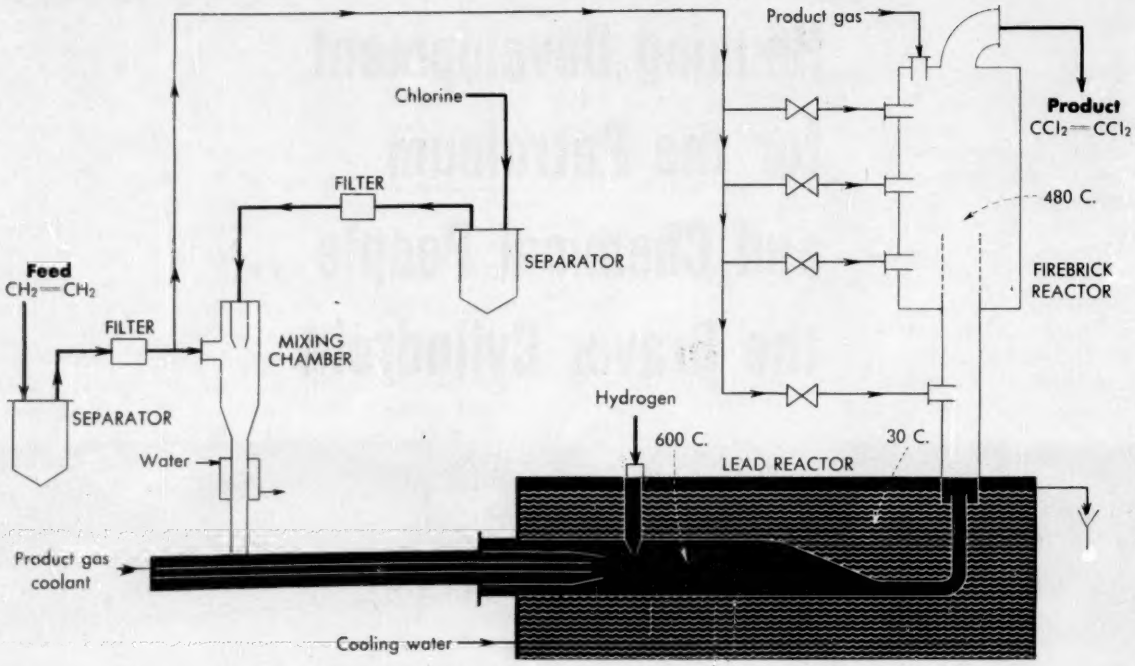
Graver Tank & Mfg. Co.

EAST CHICAGO, INDIANA

PLANTS AND OFFICES ACROSS AMERICA

Graver

ONE OF THE UNION TANK CAR COMPANIES



Something old, something new, something borrowed can be found in the . . .

Huels Perchloroethylene Process

Resembling a big torch, the reactor produces the compound in a few seconds and eliminates chlorine waste. Conversion: 70%.

Last month in Recklinhausen, *CE* heard the latest news about vapor-phase chlorination:

By shooting ethylene and chlorine into an ordinary lead pipe and igniting the mixture with a little hydrogen gas, Chemische Werke Huels has become one of Germany's biggest producers of perchloroethylene.

Interestingly enough, the idea for this process isn't at all new but goes back some 130 years, when Faraday and Regnault originally synthesized the compound by passing chlorohydrocarbons through red-hot tubes.

Perchloroethylene, a heavy, colorless, nonflammable liquid extensively used as a dry-cleaning fluid and solvent for organic materials, has been tied up for many years to the expensive acetylene route, which involved four reaction steps. The new Huels process[1] is actually a two-step affair, but both steps occur simultaneously.

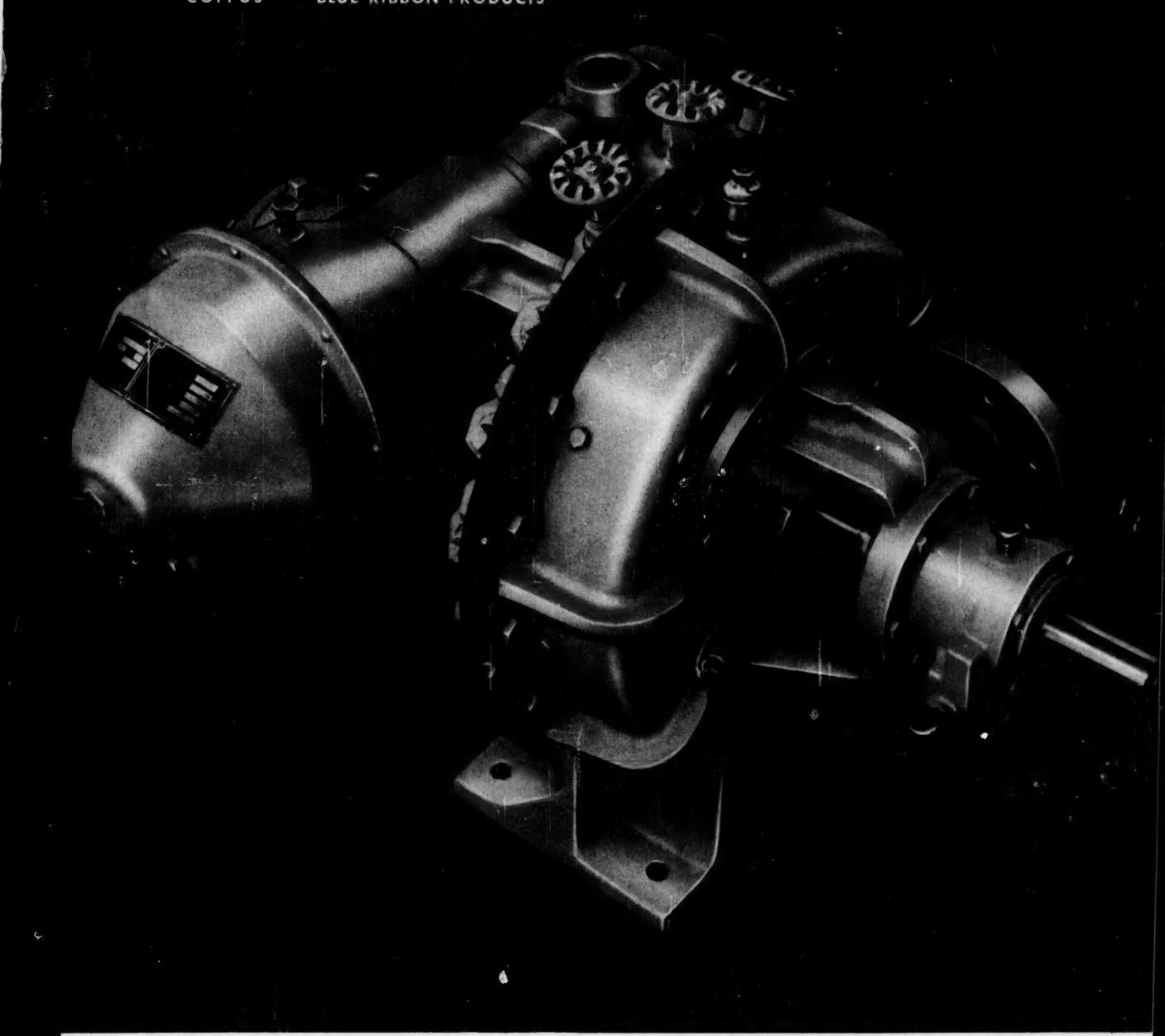
Only a portion of the feed gas is reacted with chlorine in a lead reactor. The rest, about 10% C_2H_4, is chlorinated in a second reactor.

In some respects, this is similar to the Pechiney process[2] operating at St. Auban, France. Engineered by Scientific Design Co. of New York, the Pechiney plant chlorinates hydrocarbons in a furnace at 480-650 C., then quickly quenches the products in aqueous HCl, which is one of the byproducts.

Huels, also working in the same temperature range but using the product gas as cooling medium, has completely redesigned the reaction furnace into two separate units—separation that assures 100% chlorine conversion—and feeds the reactants into the system in a very original manner.

▶ **Quick Feeding** — Chlorine and ethylene gas are pumped into a water-jacketed mixing chamber. The mixture then passes through a nozzle and—ignited by hydrogen—burns inside a 5-ft. piece of lead pipe immersed in a water cooling bath. Although the flame temperature goes up to 600-650 C., the material won't corrode because a protective layer of $PbCl_2$ forms.

COPPUS BLUE RIBBON PRODUCTS



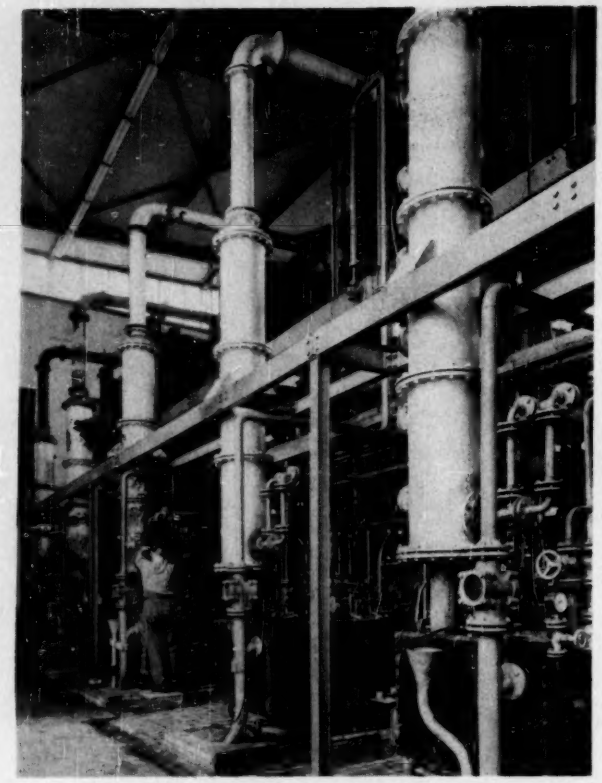
Coppus Horizontal Steam Turbine

NEW RUGGED DESIGN—BLUE RIBBON RELIABILITY!
Here's a new dimension in turbine performance! Coppus brings you a new rugged stability of design . . . a new measure of reliability in a complete range of power-packed turbines, from 1 HP to 250 HP — marked with the Blue Ribbon only after each is precision made . . . precision tested. Performance features like these assure you Blue Ribbon Reliability —

A totally enclosed governor . . . totally enclosed, independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. All Coppus Products carry the same Blue Ribbon assurance of reliable performance. For further facts on turbines, send for new Catalog 200. COPPUS ENGINEERING CORPORATION, 211 Park Avenue, Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES



Huels reactors: first stage is submerged in water; vertical column is second stage.

The input velocity of the gas mixture is about 200 m./sec., giving a throughput of 100 cu. m./hr. Still burning, the mixture leaves the lead reactor and, through a 5-ft. cooler, enters the vertical firebrick reactor where fresh ethylene is also added. Here, practically all the chlorine reacts while the temperature drops to 480 C.

Unlike the Pechiney process, where cooling occurs outside the furnace, Huels controls the temperature by recycling a portion of the product gas to both units. After a water wash, the other portion of the product gas condenses into a two-layer liquid. The heavier layer of chlorinated hydrocarbons is separated from the aqueous HCl and distilled.

Although Pechiney gets more than 90% conversion to perchloroethylene, it must also cope with an undesirable excess of HCl that hampers separation.

The German process gives 70% perchloroethylene, 20% carbon tetrachloride and 10% byproducts (such as chloroform, trichloroethylene, ethane and butadiene). Although 70% conversion is obtained under normal conditions, Huels can boost the perchloroethylene yield to 85% by changing the reaction conditions. Here are the significant variables:

1. Flow rate of cooling water in the lead reactor.
2. Velocity of feed gas.
3. Flow rate of product gas that acts as coolant.

▶ **Methane Feed** — With slight modifications, this process also lends itself quite well to carbon tet production by chlorinating methane in three steps.

About 50% chlorine is consumed in the lead reactor, 10% in a 64-ft. cooling pipe, and only 0.5-1% remains unconverted in the third reactor segment.

The capacity of this system is 200 cu. m./hr. but input velocity (30-40 m./sec.) of the methane-chlorine mixture is considerably lower than that of the ethylene-chlorine feed. With methane, the yields are 50% carbon tetrachloride and 40% perchloroethylene.

Maintenance costs are reasonable. When large reactors break down, repairs are expensive because they result in production delays; the Huels reactors, which need new tubes after 12-14 months of operation, are inexpensive to repair because of their small size.

In the U. S., Diamond Alkali and Columbia-Southern have similar processes. Both Dynamit AG and Wacker Chemie, in Germany, still follow the acetylene route.

Main advantage of the Huels process over the methane chlorination method used by Dow Chemical[3] consists in the almost complete conversion of chlorine, whereas Dow has 25-40% unconverted chlorine leaving the reactor. Moreover, Huels feeds natural gas and raw chlorine of 93% purity into its plant, while Dow purifies chlorine by liquefaction and cools the reactants with pure product gas.

In Italy, Montecatini is also operating a one-step process[4]—somewhat similar to Dow's—that uses raw-product gas for cooling.—EG

References

1. German patent DAS 1,074,025; 2. U. S. 2,746,998; 3. U. S. 2,442,323 and 2,442,324; 4. French 1,105,791.

Foreign Patents Cost Plenty to Maintain

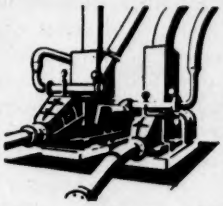
American companies pay steep prices annually just to renew and maintain their foreign patents.

According to Du Pont patent attorney R. W. Ball, speaking at a recent MCA meeting, an average large American chemical company has from 12,000 to 15,000 pending foreign patent applications and foreign patents in force. In practically all these countries, you have to pay annual maintenance or renewal fees to keep your patent in force.

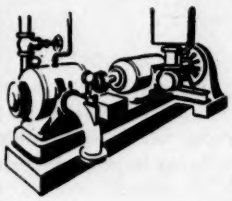
In Germany, for example, total of fees charged to maintain one patent in force for its full life amounts to about $2,435. In Russia, it's about 16,830 rubles.

FULLER EQUIPMENT

for the process industries

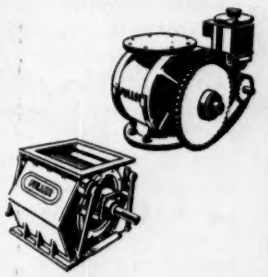


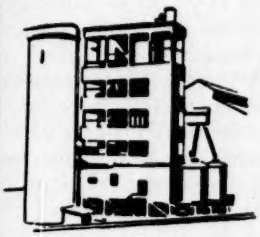
Pneumatic Materials Handling Systems. Widely specified throughout the process industries, Fuller's range of equipment offers best single source for solving problems in moving dry bulk materials pneumatically. Fuller-Kinyon Pumping Systems, Airveyor® Pressure and Vacuum Conveying Systems, and F-H Airslide® Fluidizing Conveyors are completely sealed to prevent both contamination of the product and any leakage of dust, etc., into the surrounding area. They are used to move dry, granular and pulverized materials to and from cars, ships, trailers, storage and processing points.



Fuller Rotary Compressors and Vacuum Pumps are vibration-free, can be installed anywhere, even on balconies. Fewer moving parts mean minimum maintenance. Compressors and Vacuum Pumps handle air and gases from 30 to 3300 cfm at pressures to 125 lb. gage. Vacuums to 29.95 in. (referred to 30-in. barometer).

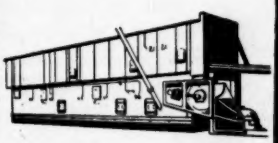
Fuller Vane-type and Roll Feeders . . . for volumetrically controlled feeding of a wide range of dry pulverized or granular materials. Also Fuller Rotary Valves . . . used under silo deck slabs and bins to permit the free flow of pulverized materials which tend to arch, such as lime and cement raw materials.





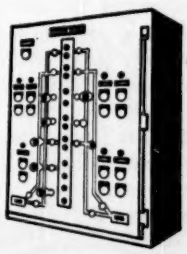
Fuller Preheaters, Humboldt Suspension Type . . . for preheating dry, pulverized Portland cement raw materials with rotary kiln waste gases.

Fuller Horizontal and Inclined Grate Coolers are compact, easily installed for fast, efficient cooling of materials such as nodulized phosphate rock, pebble lime, ores, dolomite, iron nodules and Portland cement clinker from 2800°F. or higher to any desired point within a reasonable range of atmospheric temperature.



Fuller-Material-Level Indicators signal audibly and visibly when materials reach a predetermined high or low level. Controls conveyor motors, valve circuits, etc.

Fuller Control Panels permit automatic, remote, one-man control of multiple operations. Easily-read panel permits visualizing flow of material to storage or from process bins.



Fuller equipment is designed to help give you maximum efficiency at minimum cost.
Send today for more detailed literature.

1356
G-210

For details on Fuller Product Line see Chemical Engineering Catalog

FULLER COMPANY
134 Bridge St., Catasauqua, Pa.
Subsidiary of General American Transportation Corporation
OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

Fuller
pioneers in harnessing AIR

CPI News Briefs

- Processes
- Plants
- Offices
- Companies
- International

Processes

Beryllium by continuous electrolysis has been achieved by Hungarian scientists, according to *Technika*, a scientific journal in that country. Electrolysis of a $BeCl_2$-NaCl eutectic mixture takes place between 570-930 F. in a stainless steel vessel, using a mercury cathode and a carbon anode, under an argon atmosphere. Metallic beryllium is won from the mercury amalgam by vacuum distillation at high temperature and pressure.

Sodium pyrosulfite, useful as a silage preservative, can be produced from dilute SO_2 streams (such as off-gases from a sulfuric acid plant) by absorbing the SO_2 in a circulating solution of sodium carbonate containing some sodium pyrosulfite. Precipitated pyrosulfite is removed continuously in a hydroclone; sodium carbonate is added to keep the H_2SO_3:NaOH ratio in solution about 0.85:1. Process is described by *Chemicky Prumysl*, Czech monthly chemical magazine.

Plants

Union Oil Co. of California, Los Angeles, and **Goliad Corp.,** Houston, are joint owners of a new system of facilities that extracts petrochemical-raw-material constituents from southwest Louisiana natural gas. Recently placed on stream, the $13-million project includes (1) an extraction plant at Cow Island, Vermilion Parish, La., where a raw liquid mixture is removed from gas, (2) an 88-mi. pipeline for transporting the mixture, and (3) a fractionation plant on the Mississippi River, about 26 mi. south of Baton Rouge, where mixture is fractionated.

System is said to be the largest one in the U.S. that extracts a liquid hydrocarbon mixture from gas at one plantsite and fractionates it at another. By doing so, the joint venture keeps extraction operations near the producing fields but has its fractionation plant close to natural product markets (in the Baton Rouge area).

The extraction plant can treat 450 billion-500 billion cu. ft. gas/day, extracts about 7,000 bbl./day of raw liquid. The facility near Baton Rouge, named the Riverside Fractionation Plant, is designed to handle 10,000 bbl./day of this mixture, splits it into streams containing ethane, propane, iso- and normal butanes, and natural gasoline. Capacity of the extraction plant may be increased to 600 billion cu. ft./day this year, and design of the Riverside facility has allowed for future doubling of capacity.

Texaco Inc. will build a benzene plant, with capacity up to 30 million gal./yr., at Port Arthur, Tex. Facilities will include a catalytic reforming unit, an extraction unit, and treating and fractionating equipment. Plant is expected to go on stream the second quarter of 1962; some of its output will be used captively, for manufacture of cumene.

Kaiser Aluminum & Chemical Corp. will construct a $1.4-million plant to make aluminum fluoride at the firm's works in Gramercy, La. Product is used with cryolite in electrolytic reduction of alumina to primary aluminum, and the new unit is part of a Kaiser program to integrate the company's sources of important raw materials. Construction of the facility is scheduled to start in mid-1961, to be completed in the third quarter of 1962. It will be erected adjacent to existing alumina and caustic-chlorine plants at Gramercy. Raw-material fluorspar and sulfuric acid will be shipped to the plant by water, and special aluminum hydrate will be supplied from Kaiser's alumina plants.

Gulf Oil Corp.'s first major petrochemical unit at its Philadelphia Refinery, a multimillion-dollar oxo alcohol plant, is nearing completion. One of the largest plants of its type ever built, it will produce octyl and decyl alcohols from heptene and nonene by a high-pressure process developed by the company. Process requires large amounts of carbon monoxide and hydrogen, which will be generated by separate units. Design of these units and engineering and construction for the over-all oxo alcohol project is being handled by Badger Mfg. Co., Cambridge, Mass.

Freeport Sulphur Co., New York, has started operating a new sulfur mine at Louisiana's Lake Pelto, about 60 mi. southwest of New Orleans on the marshland shore of the Gulf of Mexico. Company is mining the deposit with a barge-mounted plant.

Celanese Plastics Co., division of Celanese Corp. of America, is leasing a plant at Alta Loma, Calif., in which it will make blow-molded polyethylene containers for packaging household detergents and other materials. Formerly operated by B. P. Johns Furniture Co., the facility occupies a 4-acre site and has 90,000 sq. ft. of floor space. The leasing marks Celanese Plastics' first manufacturing operations on the West Coast.

Monsanto Chemical Co. has broken ground for a multiproduct chemical plant that will occupy a 650-acre site on the Delaware River in Gloucester County, N. J. Among the plant's products will be benzyl chloride, phthalic anhydride, and a plasticizer for vinyl plastics tradenamed Santicizer 160, all of which are scheduled to be in production by early 1962. Catalytic Construction Co., Philadelphia, will handle part of the initial site-development and erection of manufacturing facilities.

Monsanto has also announced that construction is due to be completed this month on a new unit

MORE CPI NEWS BRIEFS
(Continued on page 134)

NEW FROM ENJAY

HEXYL ALCOHOL

● A raw material for the chemical industry

SPECIFICATIONS FOR HEXYL ALCOHOL

Purity, as Hexyl Alcohol (Wt. Per Cent)	min. 98.0
Specific Gravity (20/20° C.)	min. 0.819
	max. 0.821
Acidity as Acetic Acid (Wt. Per Cent)	max. .001
Color (Pt —Co)	max. 10
Water (Wt. Per Cent)	max. 0.10
Carbonyl Number (Mg KOH/g)	max. 0.2
Distillation: °C.	
Initial	min. 149
Dry Point	max. 158
Appearance	Clear and free of suspended matter

Hexyl Alcohol is another product resulting from the vast research and development program being conducted by Enjay to serve the chemical industry. Of special interest to vinyl plastic compounders are the phthalate esters of Hexyl Alcohol which exhibit high efficiency and good solvating properties, making them ideal as clandering aids. Hexyl Alcohol has many other promising applications as a raw material for *flotation agents, lubricant additives, degreasing fluids, brake fluids* and *agricultural chemicals*. Enjay also markets decyl, tridecyl and isooctyl alcohols as chemical raw materials. Whenever you specify Enjay, quick, dependable deliveries are provided from conveniently located distribution points. For more information, write to 15 West 51st Street, New York 19, N. Y.

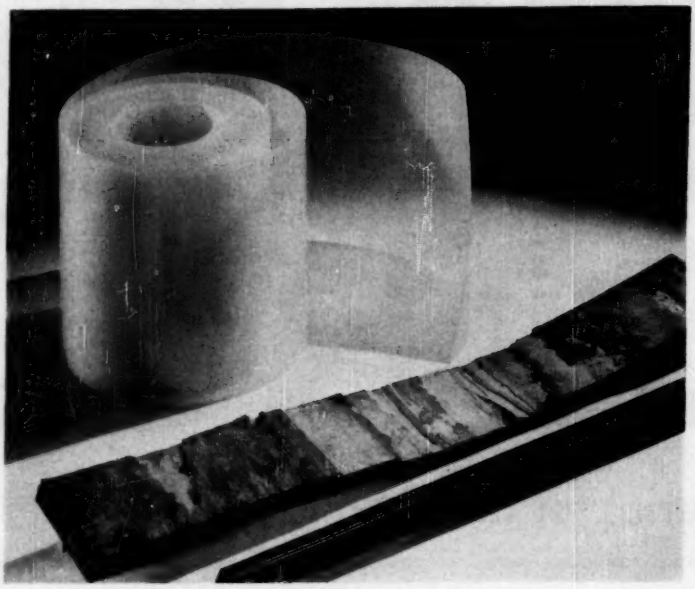
EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY PETROCHEMICALS

Oriented nylon doubles life of conveyor belts



The beat-up piece of belt, center, was still in tunnel-construction service when it was taken off the job. It has outlasted previous belts by more than 100% and required less maintenance. In round-the-clock operation, sharp, heavy rocks, gouged from the tunnel face, were dropped on the belt and conveyed to a discharge point.

Key to the unusual strength properties of the belt is the orientation process that makes the normally tough nylon even tougher. The process increases the tensile strength of nylon and removes much of its residual elongation. Lack of elongation is an important factor in belt construction because there is no need to shut down machines to tighten the belt. Also, the flex strength of the new belt allows smaller and less expensive pulleys.—**Spencer Chemical Co., Kansas City, Mo. 58A**

Polysulfides and epoxies

New formulations add impact resistance to epoxies.

A new group of epoxy resins, called Tipox, has recently entered the market as a result of an agreement between Thiokol Chemical and Union Carbide.

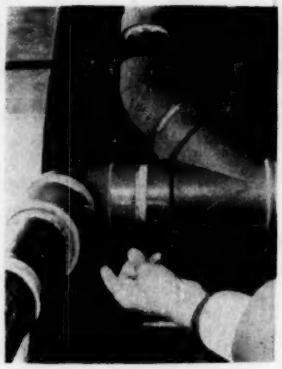
Tipox resins, made from polysulfide liquid polymers and epoxy resins, are 100%-reactive thermosetting liquids that form cured solids or films upon the addition of a suitable hardener or catalyst.

Because of many available curing agents, these resins can be custom-tailored to provide the physical, chemical and electrical properties necessary for a specific job. But they are specially adaptable for making long-lived, chemically resistant coatings, tough and stable castings and high-strength structural adhesives.

These resins can be cured by compounds that contain active hydrogen atoms or by self-reaction in presence of a catalyst. The most common curing agents for Tipox resins can be found among the primary and secondary amines because these are usually low-viscosity liquids that—easily blended with the liquid epoxies—cure at room temperature.

Acid anhydrides, such as phthalic anhydride, are other curing agents, used principally in electrical potting and encapsulation.

With organic amines, low-viscosity polysulfide polymers give varying degrees of flexibility to the Tipox resins. For example, by changing the amount of polysulfide, Tipox resins can acquire tensile strengths varying from 3,000 to 7,000 psi., elongation from 10 to 30 psi., and Shore D hardness from 69 to 80. The impact strength changes even more from 0.5 to 71.5 ft.-lb. — **Thiokol Chemical Corp., Trenton, N. J. 58B**



Plastic piping

Unplasticized PVC moves in on waste drainage piping.

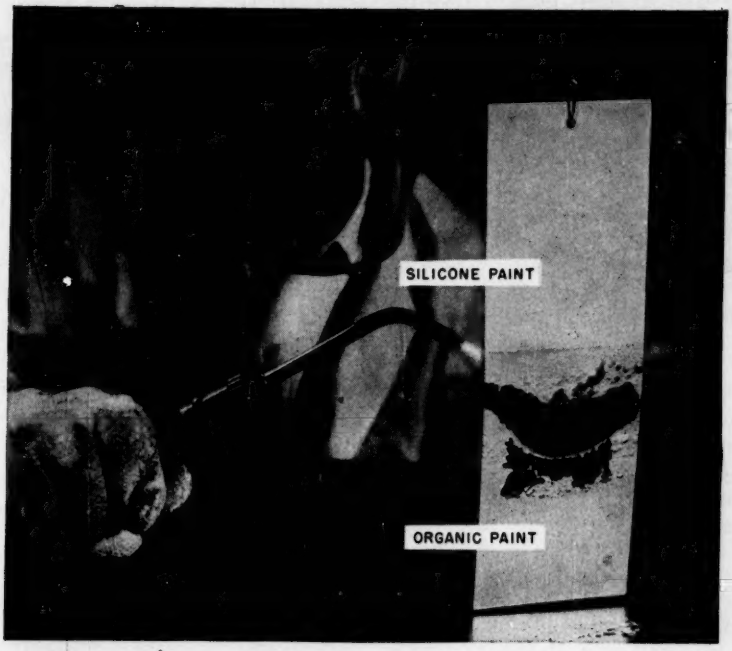
Pipefitters report that unplasticized polyvinyl chloride pipes are easy to handle and can even be joined by hot lead without damage to the plastic.

UPVC pipes were recently installed in a photograph laboratory to handle drainage of acetic acid, potassium ferrocyanide, potassium thiosulfate, sodium hydroxide and nitric acid—chemicals that are generally conceded to create the worst conditions for pipes.

Inexpensive to install because of their light weight, the new pipes are sturdy, low fouling and have proved their resistance to corrosion from acids, solvents and bases. They are manufactured by

SILICONE NEWS from Dow Corning

New Paint For Hot Spots



Silicone-based paints stay put ...resist corrosion, weathering

Guarding metal surfaces from weathering and chemical attack is tough enough. Keeping them protected when surface temperatures climb to 700 F, 800 F — even 1000 F — is tougher still. Most paints fail rapidly, blister and peel. But paints based on Dow Corning Silicones retain their protective properties, even on the hottest jobs.

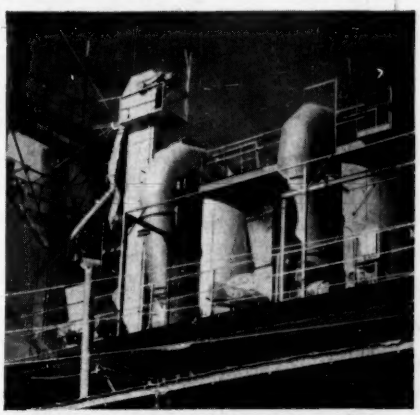
Whether the surface stays hot, or shuttles between hot and cold, makes no difference to a silicone paint. Here's a new kind of protective coating . . . one that you can depend on to provide real protection, withstand oxidation, corrosive atmospheres or weathering. When paint lasts like this — from 25% to 100% longer — you save money because (1) less paint is required; (2) costly downtime and labor are greatly reduced.

Another plus: Silicone-based paints are available in a wide range of colors. This means you can carry color-coding over onto hot equipment without worrying about early paint failure. To new product designers, this feature means finishes that resist chalking, checking, fading — retain their original beauty and protection.

For protecting a "hot spot" or a "hot product", it'll pay you to use paints made with Dow Corning silicone resins. Write today for more information.

"After 5 years, silicone paint still protects bronze-melting furnace. Organic paints failed within days after application."
BEARING MANUFACTURER

"After two years, mufflers coated with silicone paint are still in good shape. Organic paint used on similar 500 F mufflers burned away long ago."
PUBLIC UTILITY



"By far the most satisfactory paint we have ever used on kilns and stacks with surface temperatures of 650 to 750 F."
BASIC CHEMICAL MANUFACTURER

Send for illustrated brochure, "Why Silicone-Based Paints Mean Less Maintenance", plus list of suppliers. **Address Dept. 1813**

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

a special injection molding method in sizes up to 4 in., and all plastic-to-plastic joints are solvent-cemented for leakproof connections. —**Tube Turns Plastics Inc., Louisville, Ky.** 58C

Liquid neon

Ideal refrigerant will soon be available.

If you have been searching for a refrigerant that boils at —400 F, is inert and still has a high capacity for absorbing heat, liquid neon is your answer.

The 10-liter container is the first shipment of the refrigerant that Linde is making. Valued at $2,500, it will be used in airborne radiometers that RCA is developing for the U. S. Air Force. In these infrared detection devices, liquid neon will give the subcooling needed for maximum effectiveness.

In the container, the neon is shielded by a layer of high-vacuum laminated insulation and 13 liters of liquid nitrogen in two concentric outer shells. Liquid neon boils at —410.8 F and, changing from liquid to gas, absorbs 3½ times more heat per unit volume than liquid hydrogen and 40 times more than liquid helium, the only two liquids that boil at lower temperatures.

Commercial quantities of liquid neon for wider application in electronic components should soon be available.—**Linde Co., Div. of Union Carbide Corp., New York.** 60A

Silicones

Sprayed on ingot molds, silicones improve ingot surface quality

Used as mold washes in the steel industry, two new silicone coatings are speeding up the manufacture of ingots while reducing metal losses.

Somewhat similar to milk in appearance, XM-2020 consists of silicone solids emulsified in tap water. The other, called XS-4017, is a silvery-gray liquid made up of a silicone compound dissolved in chlorinated hydrocarbons.

Applied to ingot molds with a spray gun, these silicones impart non-sticking properties to the mold surface so that splashes of molten stainless or specialty alloy steels won't adhere to the walls but easily flow back into the melt. Now free of oxide-coated metal splashes, mold walls give smoother surfaces to the ingots by reducing such defects as pits, inclusions, folds and scale.

In some grades, the improved ingot surface allows full rolling of the billet to desired size in the initial soaking heat, without interrupting the rolling operation to cool, scarf and reheat the billet.

The XM-2020 silicone emulsion cannot be applied to molds hotter than 600 F, because the fluid base undergoes thermal and oxidative degradation and the coating will gradually lose its effectiveness if the molds are held for several hours at such temperatures. This drawback, however, is easily overcome by allowing the molds to go through a cooling cycle after stripping the ingots.—**General Electric Co., Waterford, N. Y.** 60B

Fuel additive

Product won't leave deposits in combustion chambers.

Oil formulations that incorporate a new detergent additive, to be known as Series 1,200, have boosted the performance of gasoline and diesel engines because of the significant reduction in surface ignition brought about by the no-ash content of the additive. Selling at 5¢/qt. above the current price of similar products, this new additive claims to be the first in preventing the sludge and wear engendered in slow-speed, stop-and-go driving. In addition, it promises to reduce cylinder wear to half that given by alkaline ash-forming detergent oils.

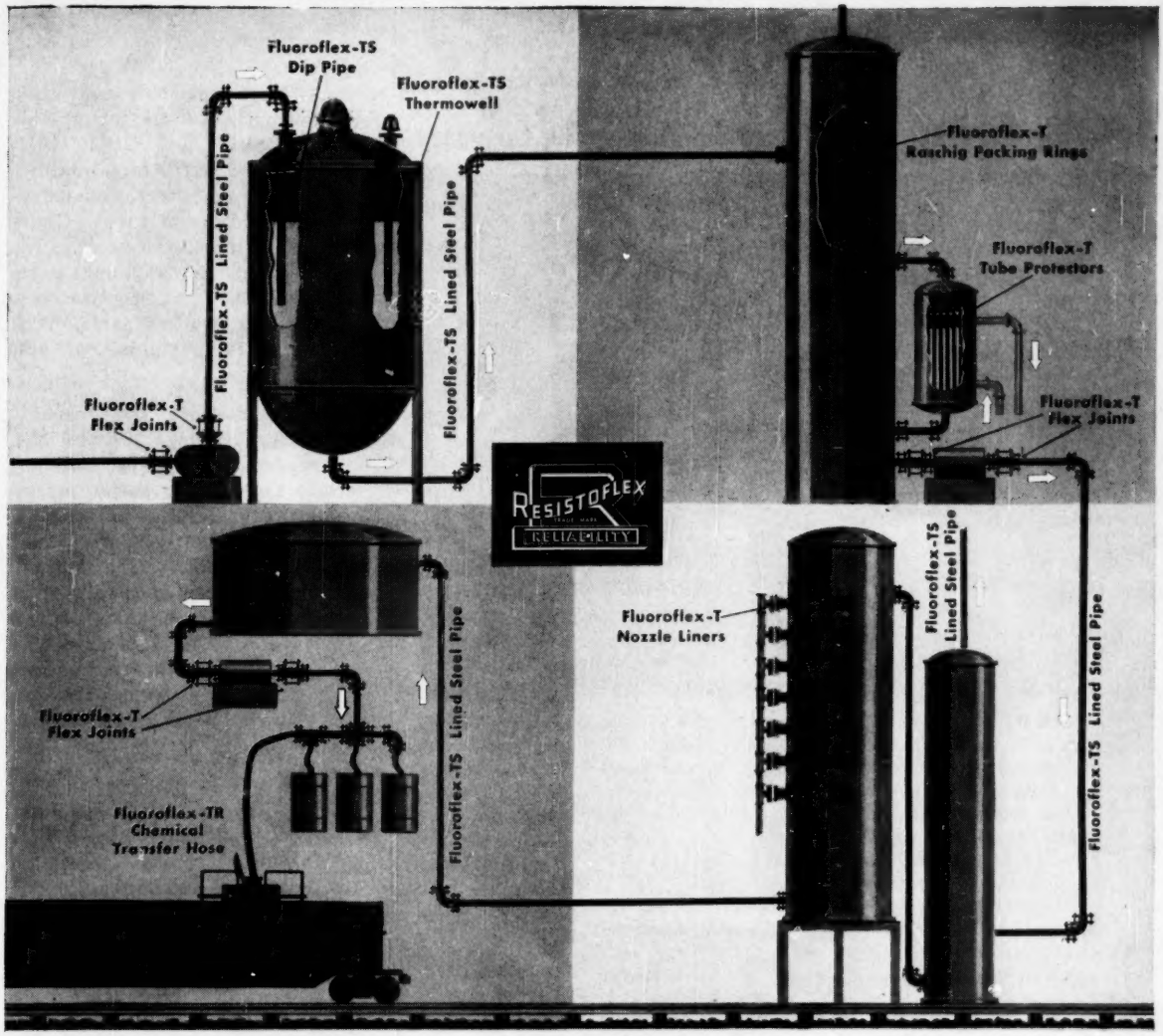
Key to the development: a patented polymeric additive, with active chemical groups (such as a zinc-phosphorus oxidation inhibitor) that suspend the products of partial fuel combustion and prevent them from depositing. This action, therefore, will control wear and rust besides satisfying the performance requirements in heavy-duty gasoline and diesel engines. At the same time, there will be a minimum of detergent-ash-induced rumble. — **Oronite Div., California Chemical Co., San Francisco.** 60C

Newsworthy Chemicals

Page number is also reader service code number

Orien'ed nylon doubles life of conveyor belts....58A
Polysulfide-epoxy formulations for coatings, adhesives....58B
Unplasticized PVC piping withstands severe corrosion....58C
Liquid neon makes ideal refrigerant....60A
Silicone mold coatings improve ingot surface quality....60B
Fuel additive won't leave deposits in combustion chambers....60C
Anticorrosion coating protects pickling tanks for years....62A
Long-chain alkyl bromides now available....62B
Diatomaceous earth aggregate finds use in chromatography....62C
Five nonionic surfactants enter the market....62D
Polypropylene polymers enter piping manufacturing....62E
Organic algaecides are fifty times more effective than $CuSO_4$....62F
Hippuric acid is available in high-purity grades....62G
Epoxy compound facilitates work on large laminates....62H

For more details use Reader Service Card



HERE'S WHY corrosion-proof fluid-handling components of FLUOROFLEX-T (TEFLON) assure production savings, non-contamination:

Fluoroflex®-T Piping Products as shown above can be used with complete and proven assurance that they will not corrode or build up solids which can contaminate sensitive products. Specially processed of Teflon® resins by patented Resistoflex methods, they can handle the most difficult materials up to 500°F. They are completely resistant to any chemical except high-temperature fluorine and the molten alkali metals.

Fluoroflex-T Piping costs no more on an installed-cost basis than other corrosion-proof systems in common use today. Initial material costs have been lowered by recent price reductions made possible by advanced technology and increasing volume. Installation costs are inherently low as a result of skillful design which features easily-bolted-together units with prefabricated, flanged sections.

Fluoroflex-T Piping costs LESS on a performance basis. Savings in operation are assured—with decreased maintenance, long service life, and the elimination of process headaches and downtime.

So, if *you* have problems of corrosion—want to reduce maintenance or replacement costs and eliminate process downtime or product loss—consult Resistoflex. Write for more information today.

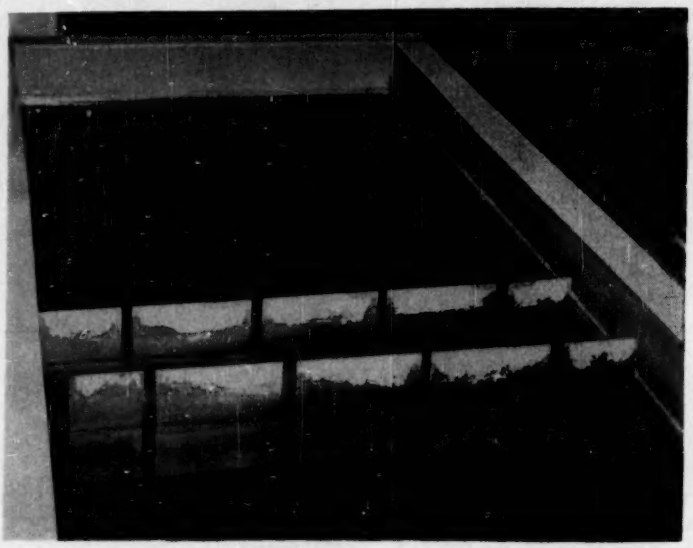
RESISTOFLEX
CORPORATION

Complete systems for corrosive service

Plants **in Roseland, N. J. • Anaheim, Calif. • Dallas, Tex.**
Sales Offices **in major cities**

®Fluoroflex is a Resistoflex trademark, reg. U. S. Pat. Off.
®Teflon is DuPont's trademark for TFE fluorocarbon resins.

Anticorrosion coating protects pickling tank for years



This metal pickling tank containing a 15% H_2SO_4 solution showed no sign of corrosion after a year of constant contact with the acid.

Previous saran coatings did not provide the necessary protection, and every four to six weeks the welded joints of the tank needed repairs. A new coating, Coro Gard—1707, solved the corrosion problem. When applied to unprimed steel, aluminum, copper, concrete and even wood or glass fibers, Coro Gard air-cures to a tough rubbery protective film that fights oxidation, abrasion and severe weather.

The coating doesn't require a catalyst for curing and because of its gel-type consistency can be applied with a brush without even diluting or stirring. It is particularly impervious to 20% HCl or H_2SO_4 solutions, salt water and alkalis at continuous service temperatures up to 120 F.—**Minnesota Mining and Mfg., St. Paul, Minn.** 62A

Briefs

N-alkyl bromides, cetyl, hexyl, myristyl and stearyl, are long-chain compounds that impart germicidal or algicidal activity to quaternary derivatives. Other short-chain compounds such as ethyl and butyl bromides act as alkylating agents to form organometallics or pharmaceutical intermediates.—**Michigan Chemical Corp., St. Louis, Mich.** 62B

A Flex-calcined diatomaceous earth aggregate, SE-30 coated Gas-Chrom, used as packing in a chromatograph column, can separate steroids very efficiently. With this packing, complete separation of cholestane, cholesterol, α-sitosterol, stigmasterol and β-sitosterol mixture has been obtained with virtually no tailing.—**Applied Science Laboratories, Inc., State College, Pa.** 62C

Five nonionic surfactants for paints, detergents, cosmetics, rubber and textiles have been prepared by reacting ethyiene oxide with dodecyl phenol and trimethyl nonanol. These surfactants, called tergitols, are soluble in water, aromatic and aliphatic hydrocarbons.—**Union Carbide Chemicals Co., New York.** 62D

Polypropylene polymers, Sustained-Heat Grade 1041 and 1044, now carry National Sanitation Foundation approval for potable water applications. Grade 1041, designed for extrusion, qualifies for high-temperature, chemical-resistant pipes and tubes. Grade 1044, for injection molding, is specified for many appliance parts in dishwashers, clothes washers, and for automotive parts.—**Avi-Sun Corp., Philadelphia, Pa.** 62E

Algaecides of the organic arsenic type, Ansar 201 and 354, are reported fifty times more effective than copper sulfate as inhibitors of chlorella, CMU-resistant algae, Square-D and black algae. Because they maintain their effectiveness even when used in concentrations as low 0.5 parts per million, both algaecides are nontoxic and can be fed to swimming pools and water cooling towers.—**Ansul Chemical Co., Marinette, Wis.** 62F

Hippuric acid ($C_6H_5CONHCH_2CO_2H$), an important intermediate in the manufacture of several drugs, is now commercially synthesized in high-purity grades. This product comes as a white, microcrystalline powder, with a melting point ranging between 187 and 189 C.—**Aceto Chemical Co., New York.** 62G

Epoxy resin Epotuf ED-1025 facilitates work on large open laminates, in flooring, topping or surfacing applications, because it is a practically odorless and nonvolatile liquid. With a viscosity below 1,000 cps., Epotuf boils at approximately 150 C. at 5 mm. Hg pressure (ordinary low-viscosity epoxies boil at room temperature under similar vacuum). The resin has electrical and coating uses.—**Reichhold Chemicals, Inc., White Plains, N. Y.** 62H

For More Information about any item in this department, circle its code number on the Reader Service Postcard (Page 169)

No fingerprints allowed

To make sure you get the premium quality you pay for when you buy stainless steel pressure tubing, we give it the white glove treatment. Our inspectors actually wear white gloves while working on these tubes. It's typical of steps taken to assure excellent surface finish and high internal quality.

You're assured of highest value when you buy Timken® stainless steel pressure tubes because:

Special techniques, unique in the industry keep physical properties and chemical composition at maximum uniformity.

You can select from a wide variety of sizes and analyses of tubing—many available nowhere else—to suit your needs.

You can call on the services of acknowledged experts in the field of stainless steel pressure tubing.

Call in Timken Company metallurgists to get the most for your money. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

TIMKEN®
***Fine Alloy* STEEL**

TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES

YOU PICKED THESE AS MOST INTERESTING

In case you missed them the first time around, here are the equipment items that evoked the most interest from readers, as measured by the number of inquiries each attracted. From Nov. '59 through Aug. '60, scrubbers, pumps, flowmeters were tops.

Floating-bed scrubber

Highly-active bed scrubs solids from gases without clogging.

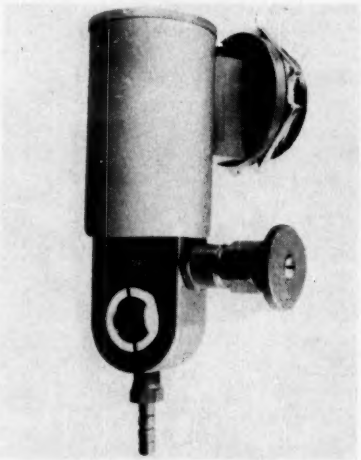
Visualize a multitude of 1½-in.-dia., low-density spheres rising, falling, floating and jostling each other within a confined area. A marathon table-tennis match gone haywire? . . . No. The key components of a new wet scrubber? . . . Yes.

Sandwiched between two retaining grids within the scrubber, the spheres form a churning, floating bed that promotes excellent contact between the scrubbing liquid and particulates or fumes being removed from the feed-gas stream. High bed mobility also prevents clogging of the unit—the constant rotation and tumbling action of the spheres scrubs away even tacky solids. Channeling is impossible.

▶ **Many Impingment Targets**—Feed gas to be cleaned travels upward through the floating bed, countercurrently to liquid flow from the distributors. Liquid, gas and particulates impinge and mingle vigorously at the spherical surfaces.

Adjustment of the flow rate of recirculating liquor allows operation over a wide range of throughputs. Particulates and absorbed chemicals are tapped off at the unit's bottom. If required, increase in depth of the floating bed can up over-all efficiency, with only a moderate resultant rise in pressure drop.

▶ **Materials and Sizes**—Aerotec offers its floating-bed scrubbers with body and gridwork fabricated of virtually any construction material—from wood and plastic to lead-lined steel. The spheres, which can vary considerably in size and density, are normally 1½ in. in diameter and fabricated of special plastics.—**Aerotec Industries, Inc., Industrial Div., Greenwich, Conn.** **64A**

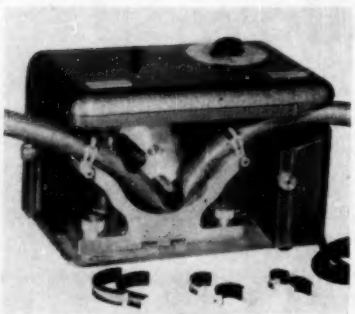


Constant-head feeder

Unit feeds set rate from drums despite varying liquid head.

New gravity metering device attaches directly to standard 2-in. drum bung, feeds liquids from drum at set rate, regardless of liquid level. Molded of Teflon and PVC, it can also be used for vacuum line feeding.

Flow rate, set by sight-metering, can vary from 1 drop/min. to 10 gal./hr. Special locking ring makes drum changeover possible without tools.—**Sterling Norcross Co., Bloomfield, N. J.** **64C**



General-purpose pump

Flexible hose is pulsed to move solids, liquids and gases.

Solids, liquids and gases are moved by positive displacement in new pump that has no glands or return valves. Revolving arms compress flexible tube, squeeze contents through tube from cc./min. to 500 gal./hr.

Pumped material passes only through hose, hence never touches any other working parts of the pump. Motors is steplessly variable to 200 rpm., and since delivery per revolution is virtually constant, pump can meter at any desired rate within its range.

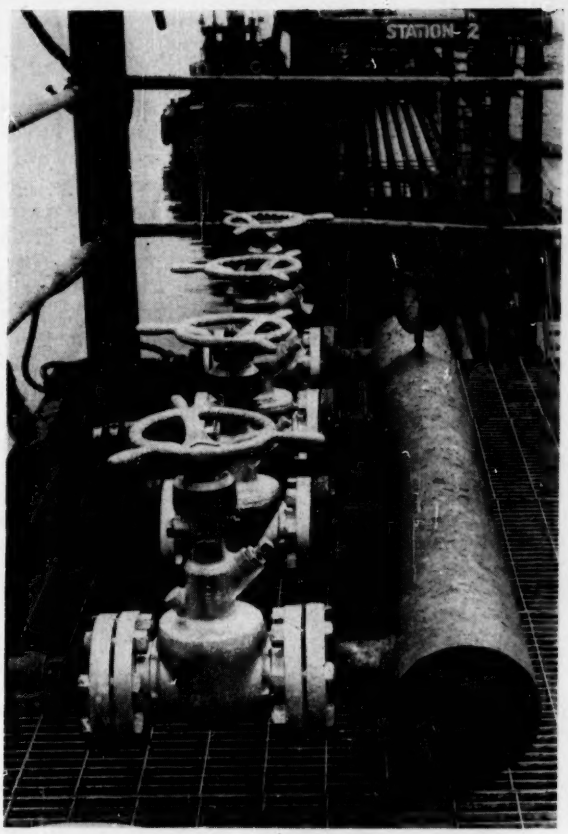
Positive-displacement nature of the pump makes it self-priming. It can act as a vacuum pump or as an oil-free compressor, can be reversed to pump in the opposite direction by flipping switch. Parts are self-lubricating.—**Schueler & Co., New York, N. Y.** **64B**

Ultrasonic flowmeter

Unit measures flow from outside pipe, never touches liquid.

Essentially developed and ready for specific customer applications is a new ultrasonic flowmeter demonstrated recently by Gulton Industries and Hersey-Sparling Meter Co. Aimed primarily at water and sewage applications, the

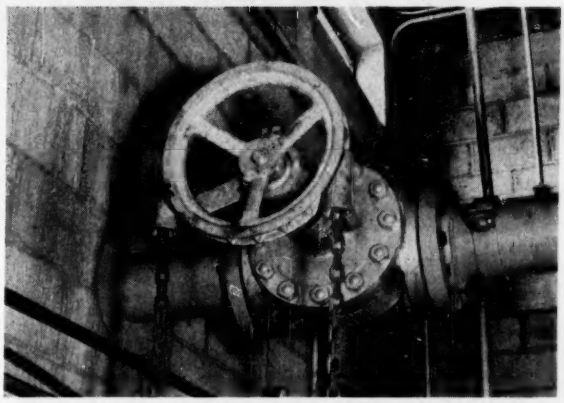
IT TAKES A TOUGH VALVE FOR TANKER CLEANING



ORBIT VALVES HANDLE SEA WATER . . . SLUDGE . . . STRONG DETERGENT

Only a tough valve — like the ORBIT VALVE — can stand up under the strenuous operating conditions of the pumping system for a tank cleaning plant at a large shipyard in Hoboken, New Jersey.

When a tanker is in for cleaning, ORBIT VALVES go into action, handling sea water mixed with strong detergent and heated to 200° Fahr. Surge on hose is eliminated through use of ORBIT VALVES — they're non-lubricated for simplified, low-cost maintenance.



Orbit Valves are widely used throughout the Chemical-Petrochemical and Petroleum industries.

ORBIT VALVES

ORBIT VALVE COMPANY

P. O. BOX 699 / TULSA, OKLAHOMA
PHONE LUther 4-4761 TWX TU 925

instrument should also find wide used in the process industries.

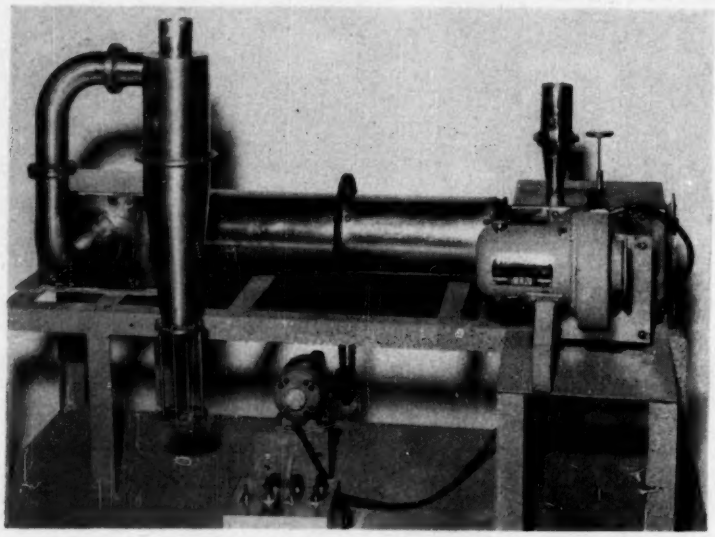
Apparatus involves no equipment in the fluid path. Thus, there are no corrosion or erosion problems, and no loss in fluid head.

Principle of operation is notably simple. Ultrasonic vibrations are directed through a section of pipe, perpendicular to the fluid path. Stream flow causes the vibration beams to be deflected, and the amount of deflection is translated into a flow reading.

This is in contrast with most previous attempts to use ultrasound for flow measurement, which measured time required for acoustic waves to travel a known distance in the fluid.

Beams are produced and received by piezoelectric ceramic transducers mounted in a section of pipe. Fabricated in lengths corresponding to standard valve fittings, pipe is normally intended as a permanent installation.

The meter is best used with liquids, as gases have a strong absorbing effect on acoustic waves of the frequency in use. Cost, at least in water-metering applications, is said to be of the same order of magnitude as that for conventional meters.—**Gulton Industries, Inc., Metuchen, N. J.** **64D**



Bench-scale dryer

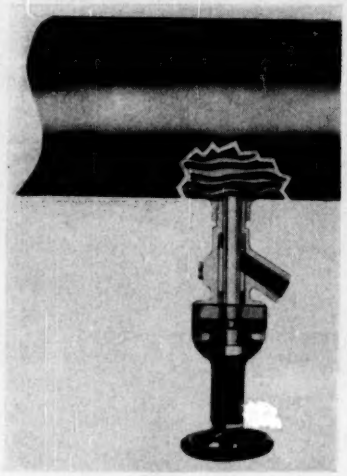
Rotating unit can simulate full-scale dryer with many variables.

Simple pan drying may take the moisture out of a sample of wet solids, but pan-dried product may not be anything like product from a continuous dryer. Engineers who want to see what continuously dried product is like can find out with a newly developed bench-scale rotary dryer that simulates big-dryer operation.

Built by Bench Scale Equipment Co., Inc., (Benco) the dryer operates with either parallel or counterflow air movement. It can be converted to a louver-type unit, thus can simulate many commercial dryers on a bench scale. Various internal conveying flights may be used to alter the lifting and air-flow patterns within the rotating tube.

▶ **How It's Used**—Bench-scale rotary drying can fill a need in three main areas: it can establish the applicability of rotary drying to a product, it can provide a means of preparing samples for product development work, and it can determine the effect of drying variables on product quality.

Benco offers the dryer as a complete package that only needs to be plugged into a 115-v. circuit to make it operable.—**Bench Scale Equipment Co., Inc., Westfield, N. J.** **66A**



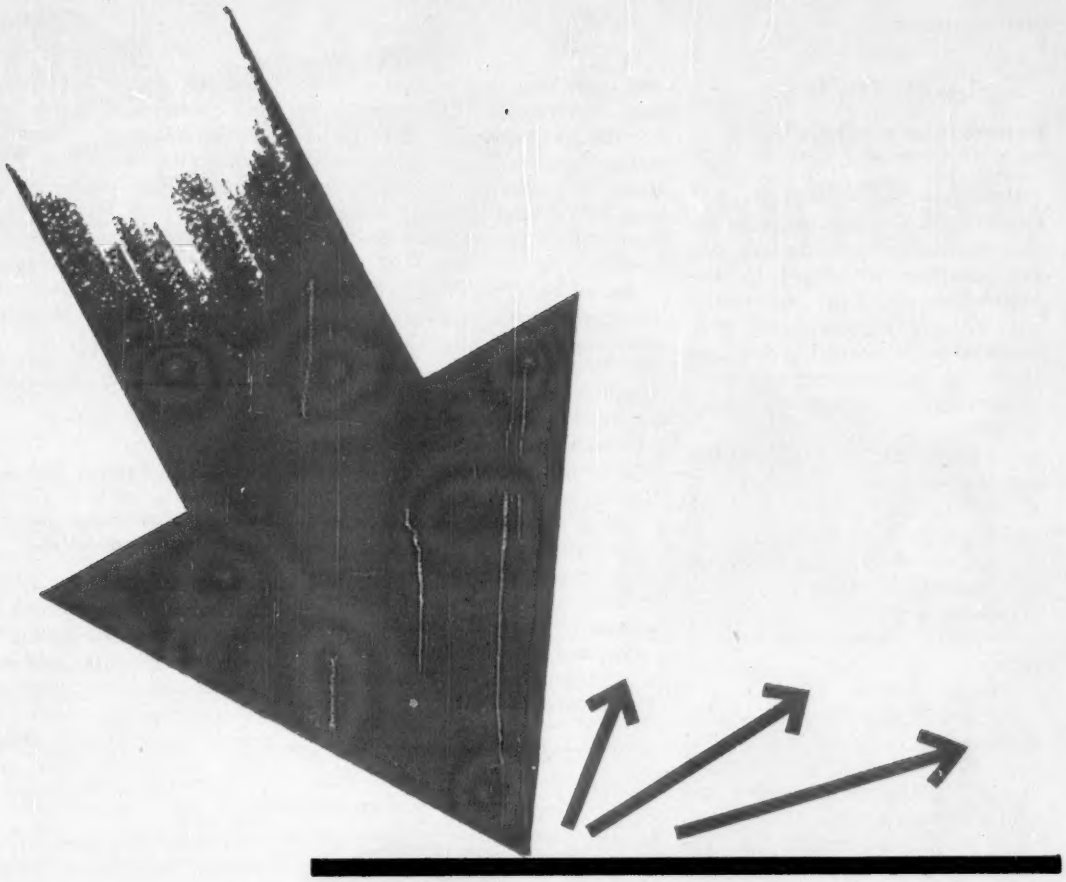
Sampling valve

Device delivers live samples, free of settlement, clogging.

New sampling valve produces live samples that are unaffected by settling or clogging in the valve body. Stainless steel valve piston, when in closed position, completely fills the valve body, thus prevents pocketing of solids during ordinary process flow. When the piston retracts, the entire valve body acts as a channel for the free-flowing sample.

Two Teflon rings, one above the discharge port, the other below, seal the valve for perfect closure. Adjustable packing gland may be tightened to recompress the rings against the piston far more positively than the old-fashioned disk seal.—**Strahman Valves, Inc., Florham Park, N. J.** **66B**

For More Information about any item in this department, circle its code number on the Reader Service Postcard (Page 169)



Metallurgical Phenomena... and the metals to cope with them.

These are the stock-in-trade of the Lukens Application Engineer—whether the problem be one of abrasive impact (symbolized above) or corrosion or pressure or structural stress or high and low temperature. Investigation of the best steels for "problem" applications has been carried on for years by the Lukens Application Research team. We would welcome the opportunity to contribute the results of this research to your own design knowledge. Please contact us in your early design stages. Call collect: Joe Proctor, Manager of Application Engineering, Extension 422, Lukens Steel Company, Coatesville, Pennsylvania.

HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB

Gas scrubber

Pressure drop is adjusted for wide range of flows.

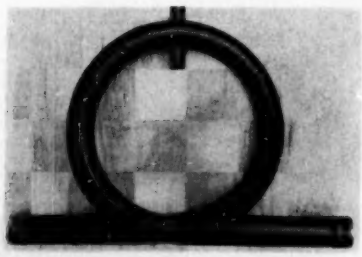
Demonstrating a flexibility that should make it a favorite with design engineers, an unusual new gas scrubber, developed by Research-Cottrell, Inc., automatically adjusts to gas flows 50% above or below normal at constant ΔP while maintaining efficiency.

Advantages of the new scrubber include:

- High efficiency for widely varying gas flows.
- Automatic operation to maintain uniform pressure drop.
- Large water passages to permit operation with very dirty scrubbing water.
- Small floor-space requirements.

Design feature of the new scrubber is a unique adjustable flooded disk centered in a conical gas duct. Upflowing scrubbing liquid impinges on a ceramic cap and flows across the disk to intimately contact downflowing gas in the highly turbulent annular zone between disk and duct, thus producing intimate contact.

This annular area can be greatly increased or decreased by small movements of the disk to provide a simple means of maintaining a uniform pressure drop when gas flow varies. — **Research-Cottrell, Inc., Bound Brook, N. J. 68A**



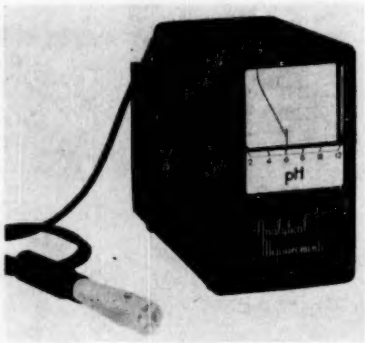
Flow element

Here's a new concept in primary elements: circular pipe section.

Fluidynamics Co. has announced development of a new primary flow element. Element consists of a 360°-type bend that creates a pressure differential across the flow section by forcing fluid to move around a circle. Experimental evidence indicates that the flow rate may be calculated from the pressure differential across the section.

Accuracy is believed to be comparable with the degree to which the dimensions of the element can be measured, thus completely eliminating error associated with empirically determined coefficients of discharge. Individual calibration is not necessary for various liquids.

When compared in cost with a functional equivalent, i.e., a complete meter run, the centrifugal element is felt to be more economical, particularly if elements one or two sizes smaller than line size are acceptable. — **Fluidynamics Co., Monrovia, Calif. 86B**



Recording pH meter

Unit makes continuous record of process system pH changes.

A combined pH meter and strip chart recorder is now available to continuously monitor and record pH levels in process streams. Instrument uses an electronically modulated amplifier that has standard radio tubes and compensates for line voltage fluctuations.

Printed at 1 in./hr., chart will record for a month. Gear change gives faster movement if needed. Chart surface contains pressure-activated coating on which a stylus makes a permanent impression, hence no pen or ink reservoir is used. Instrument serves as an indicating pH meter when the chart is shut off.

Polythylene protects the glass electrode from shock or handling. According to the manufacturer, price of $195 is low because of printed circuits and simplified design.—**Analytical Measurements, Inc., Chatham, N. J. 68C**

Distillation column

Rotating tray design permits low-pressure operation.

Materials that require minimum heat exposure or reduced temperature during distillation—hence need low absolute pressure—can now be kid-glove processed in a new column that has an amazingly low pressure drop of about 1 mm. Hg. It's not a puny laboratory column, but a full-scale commercial unit.

To eliminate pressure drop, the column's designers had to depart from conventional means of obtaining vapor-liquid contact, such as bubble-cap trays or internal packing. The radical new design achieves contact by a series of rotating trays, which fling liquid reflux droplets from the column center to the wall. Rising vapor, passing through the liquid curtain, contacts the liquid intimately, just as it does on conventional trays.

▶ **European Design**—Invented by Sweden's Stora Kopparbergs Bergslag A.B., the columns have seen extensive service in Europe, distilling tall oil, caprolactam, and other undisclosed materials. Stora has licensed Vulcan-Cincinnati to build and distribute the towers in the U.S. V-C is currently working with an unidentified firm on the tower's first U.S. application.

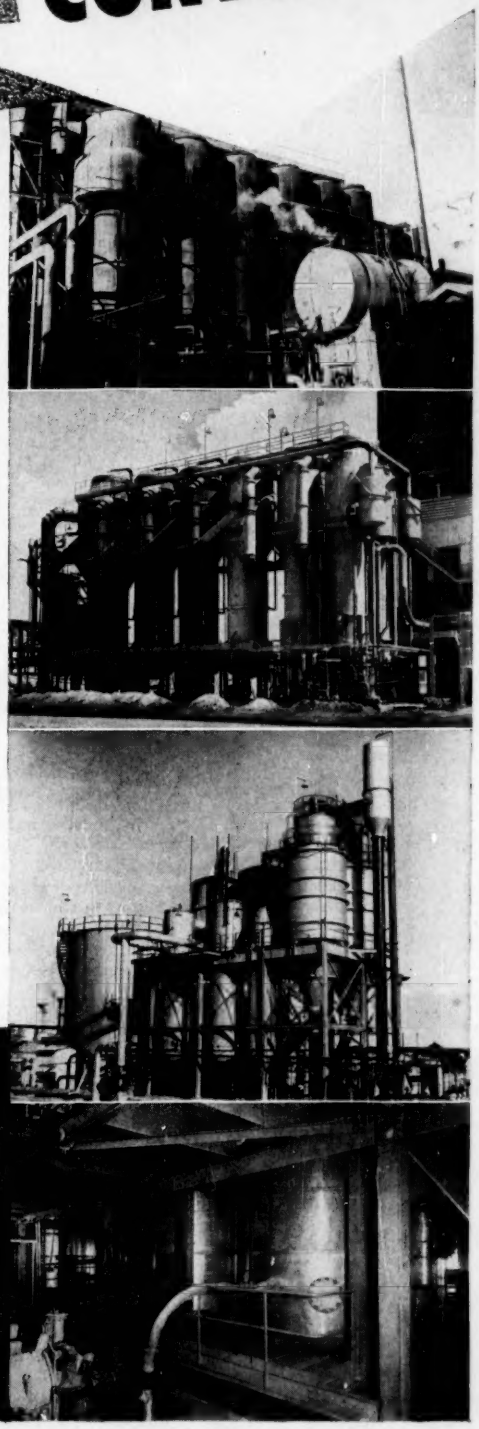
It's easy to see from an energy balance how the new column cuts pressure drop. In a bubble-cap unit, the uprising vapor must push

MORE NEW EQUIPMENT

(continued on page 148)

CB&I-built equipment keeps

HEAT TRANSFER UNDER CONTROL



In the design of heat transfer equipment such as multiple effect evaporators and crystallizers, there is no substitute for the services of an experienced "hand" —when it comes to calculating co-efficients and selecting a type which promises the most efficiency for every operating dollar.

CB&I—long the leader in the fabrication of vessels, field erection, X-ray, stress-relieving and welding—now supplements its organization with a staff of competent, experienced chemical engineers who are capable of designing heat transfer and other process equipment to suit your needs.

Whether you are contemplating a new plant, a plant expansion, or replacement of existing equipment —it will pay you to investigate how CB&I's *coordinated* services can provide equipment that is designed, fabricated, erected, put into operation and *guaranteed* under a *single* responsibility.

Write our nearest office for details on this CB&I-Engineered equipment:

Crystallizers
Evaporators
Flash Evaporation Systems
Condensers
Custom Made Heat Transfer Equipment
Vacuum Dryers
Reboilers
Vaporizers
Boiler Feed Water Equipment
Vacuum Pan Dryers

C45C

Chicago Bridge & Iron Company

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston • Kansas City (Mo.)
New Orleans • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • South Pasadena • Tulsa
Plants in Birmingham • Chicago • Salt Lake City • Greenville, Pa. • New Castle, Delaware

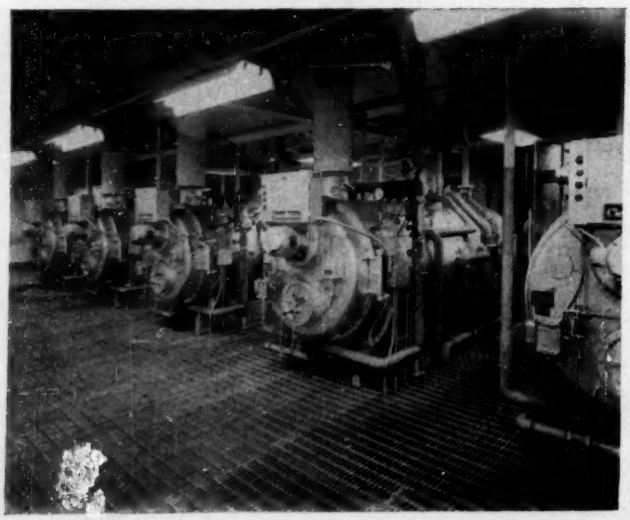
SUBSIDIARIES:
Horton Steel Works Limited, Toronto; Chicago Bridge & Iron Company Ltd., Caracas; Chicago Bridge Limited, London; Chicago Bridge Construcoes Ltda., Rio de Janeiro

REPRESENTATIVES AND LICENSEES:
Australia, Cuba, England, France, Germany, Italy, Japan, Netherlands, Scotland

you may be paying for it a second time!

$15,000-A-YEAR LABOR SAVINGS

Diebold, Inc., Canton, Ohio, century-old manufacturer of bank protection and office equipment, replaced old, coal-fired boilers with new, fully automatic, gas-fired CB boilers and saved $15,000 to $18,000 in annual manpower cost. *All five of these new boilers are operated by just one man* — other personnel have been transferred to more productive work assignments. Bill Roby, assistant plant engineer, speaks highly of the ease of installation and the compact design.



New or old, there's one thing about any boiler that's up-to-date: you have to pay today's wages for the men who tend it. This becomes out-of-line overhead if you're operating a boiler designed in the days when man-hours were far less costly.

As wages have doubled during the past two decades, one manufacturer, Cleaver-Brooks, has pioneered in making a boiler that requires fewer man-hours to operate. Today's CB packaged boilers provide a combination of labor-saving design features and performance standards that cannot be found in any other boiler — at any price.

Hinged doors, front and rear, provide for quick cleaning of the tubes. It takes only 40 seconds to remove and replace the retractable burner nozzle. Fully automatic, these boilers include electronic safety devices which release the operator for other duties. And, because some jobs require quick changeover from one fuel to another, Cleaver-Brooks boilers are designed to make this change in less than a minute.

All this is provided by Cleaver-Brooks in the most compact, fuel-saving packaged unit on the market. Sizes through 600 hp.. oil, gas and combination oil-gas firing... larger sizes in Cleaver-Brooks Springfield water-tube boilers. All models completely pre-engineered and tested as a package... expertly started for you by a trained field engineer.

Your local Cleaver-Brooks agent can supply more details. Ask him, or write for the booklet, *How to Select a Boiler.*

Cleaver Brooks®

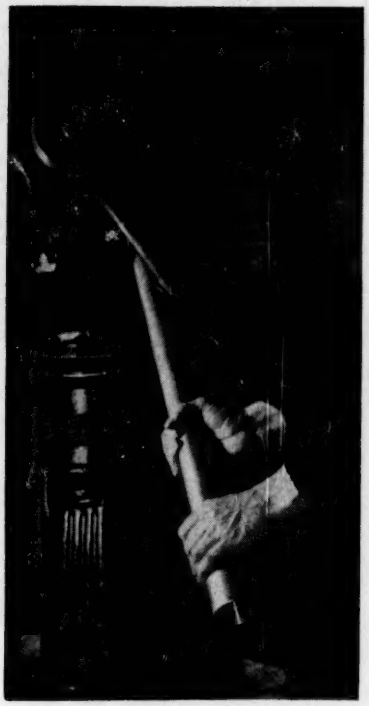
ORIGINATOR AND LARGEST PRODUCER OF PACKAGED BOILERS

CLEAVER-BROOKS COMPANY

Dept. A-345 E. Keefe Ave., Wilwaukee 12, Wisconsin

BRIEFS

A task for Fluorolube®
A better chlorine carrier
About lauryl mercaptan



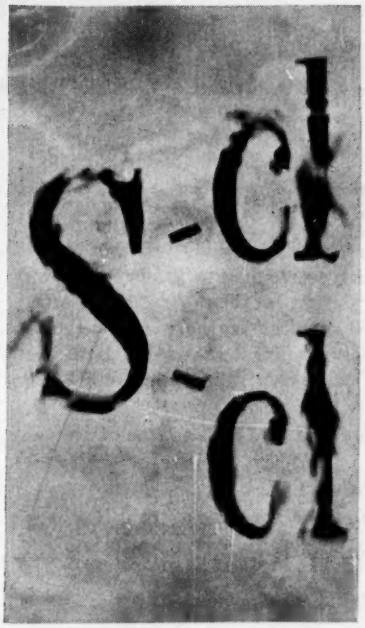
Here, obviously, is a valve that's begging for a shot of lubricant. One that's impervious to oxidants or corrosive liquids. This narrows the field to a very special kind of lubricant: the Fluorolubes (addition polymers of trifluorovinyl chloride).

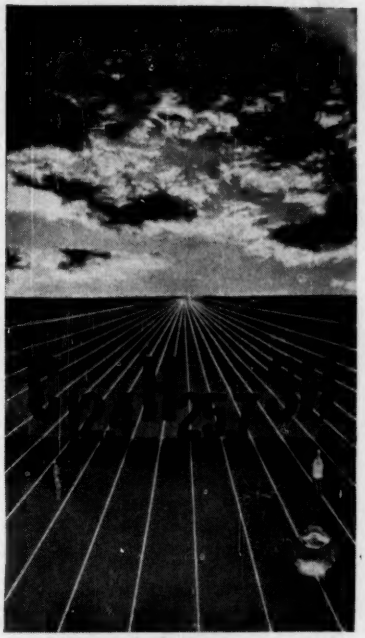
We use them ourselves on chlorine valves, and find them very good indeed. With old-style lubricants, we had to repack these valves 35 to 50 times a year. With Fluorolube packing, we do it only four or five. Of course the most spectacular uses for Fluorolubes are found in rocketry, where they are applied as coatings and lubricants for parts of missiles in contact with oxygen. They're heat-stable, too. Up to 400° F. We have some literature on Fluorolubes you can get by checking the coupon.

IF YOU WANT REACTIVE CHLORINE ATOMS

A good way to inject chlorine atoms into certain compounds is to use Hooker sulfur dichloride. Examples: chloridizing agent in metallurgy; reagent in manufacture of rubber cements and insecticides; hardener for printing inks.

Since we're in the chlorine business, our background on how to deal with chlorine atoms in usual as well as unusual ways is quite broad. Write us if you have questions—or, if you wish technical information, just check the coupon.





LAURYL MERCAPTAN, A CHEMICAL FOR IDEA MEN

Here is an interesting Hooker product used primarily as a polymerization modifier in the manufacture of "hot type" synthetic rubber. To the imaginative researcher this mercaptan may conjure up some fresh ideas in polymer chemistry. For research samples, please write on your business letterhead. For technical data sheet, check and mail the coupon below.

Typical properties

ANALYSIS:	
mercaptan sulfur	14.7-14.8%
chlorine	0.2%
LAST CRYSTAL POINT	-7°C
BOILING RANGE AT 5 MM (first drop to 95%)	108-139°C
FLASH POINT	128°C
FIRE POINT	139°C
REFRACTIVE INDEX, $N20/D$	1.4582
SPECIFIC GRAVITY AT 15.5°C	0.849

For more information, check here and mail with name, title and company address:

- ☐ Fluorolubes, Data File
- ☐ Sulfur Dichloride, Data Sheet
- ☐ Lauryl Mercaptan, Data Sheet

HOOKER CHEMICAL CORPORATION
401 Forty-seventh Street, Niagara Falls, New York

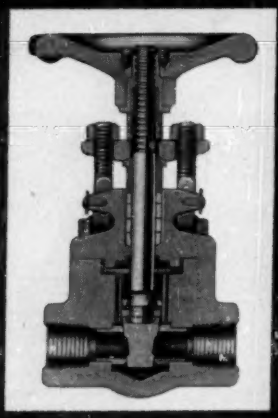
Sales Offices: Buffalo Chicago Detroit Los Angeles New York Niagara Falls Philadelphia Tacoma Worcester, Mass.
In Canada: Hooker Chemicals Limited, North Vancouver, B. C.

HOOKER CHEMICALS PLASTICS

FORGED STEEL VALVES

Recommended for:

- REFINERIES, PETRO-CHEMICAL, POWER, PROCESS INDUSTRIES
- GAUGE, INSTRUMENT, METER LINE SERVICE



"R-P&C Forged Steel Valves are designed for streamlined safety"

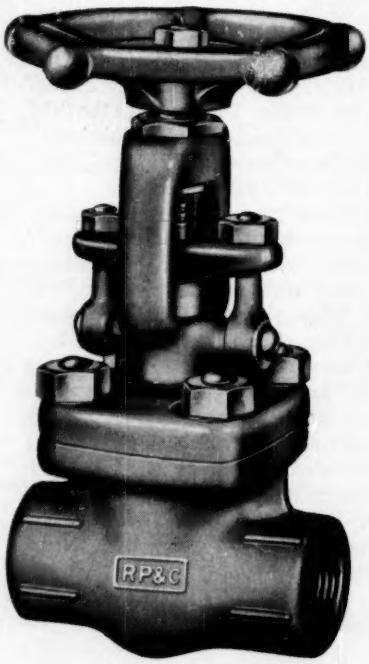
"'Streamlined safety' is the R-P&C way of saying that this Forged Steel Valve is now lower in weight yet higher in safety than ever before. Thanks to an improved design worked out with leading material specification engineers, all unnecessary bulk and weight in R-P&C Forged Steel Valves have been eliminated. **Ample metal sections** throughout the valve body still give it the highest possible safety factor."

Other new design features like these add up to a long life of trouble-free service:

- **Spiral wound gasket in bolted bonnet joint**
- **Careful heat treatment of parts for strength and wear**
- **Unique stem design to protect stuffing box packing**
- **High quality materials to prevent corrosion**
- **Precision manufacture with exacting standards**

In addition to these Forged Steel Gate and/or Globe Valves, R-P&C distributors offer users in all industries a complete line of R-P&C gate, globe and angle valves in all standard materials: electric furnace iron, bronze, bar stock, cast steel...plus many specialties.

Contact your R-P&C distributor



R-P&C VALVES

ACCO

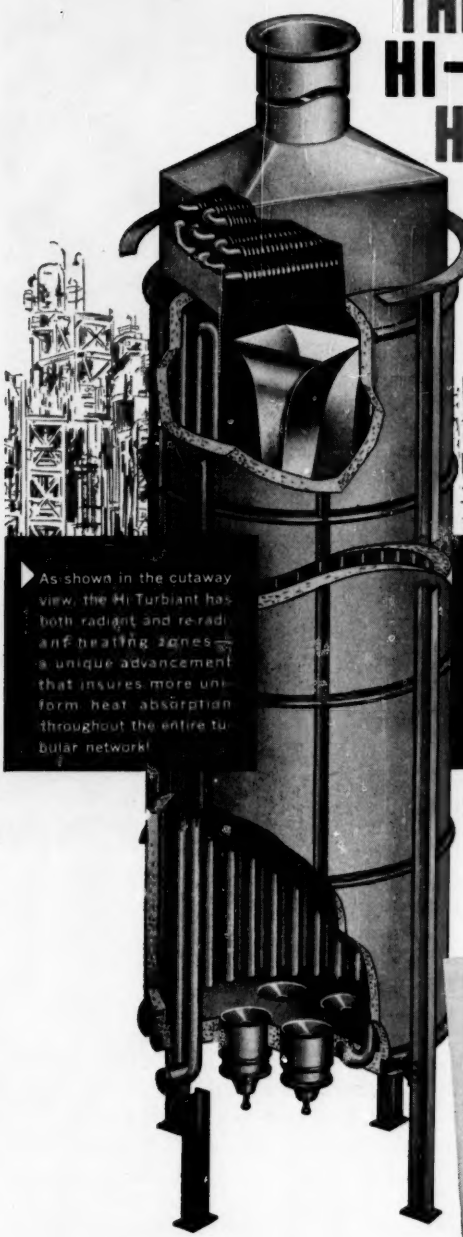
R-P&C Valve Division, American Chain & Cable Company, Inc.

Reading, Pa., Atlanta, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Conn.

HIGHER *Thermal Efficiencies . . . . .* ***GREATER*** *Savings In Industrial Process Heating!*

THE HI-TURBIANT HEATER

If you have any process operations— large or small—where process fluids are heated, directly or indirectly, investigate now the substantially greater thermal efficiencies and lower operating costs the Hi-Turbiant Heater is bringing to other processing applications similar to yours.



As shown in the cutaway view, the Hi-Turbiant has both radiant and re-radiant heating zones—a unique advancement that insures more uniform heat absorption throughout the entire tubular network!

High fluid turbulence, maintained by high-temperature pumps, reduces boundary layer vaporization and assures substantially greater heat efficiencies without vaporization problems!

More uniform heating permits greater height-to-diameter ratio—therefore fewer "hairpins" in the tube system for more efficient fluid flow, lower pumping costs, greater operating economies!

Because of these and other unique Hi-Turbiant advancements, you make multiple savings in process heating applications— savings in size of unit required, savings in fuel costs, savings in pumping costs, savings in plant space. Send for illustrated bulletin that gives detailed data and shows typical systems. *Ask for Bulletin #HT-100!*

TWO BROAD FIELDS OF APPLICATION!

1. Heating Transfer Fluids (Dowtherm, Aroclor, Hydrocarbon oils, etc.) used in heat processing.
2. Direct Firing of process streams (Rich-Oil denuding, asphalt heating, etc.) where fluids must be heated under close thermal control.

In both types of application, the Hi-Turbiant Heater brings new standards of efficiency, new savings in processing costs!

COMPLETE RANGE OF SIZES—
½ TO 40 MILLION BTU/Hr.

Also, single user "package" units 200,000 to 1,500,000 BTU/Hr.

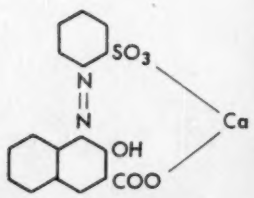
There's a Hi-Turbiant Heater to fit your requirements!

WESTERN
PRECIPITATION
DIVISION OF JOY MANUFACTURING COMPANY

1000 WEST 9TH STREET, LOS ANGELES 54, CALIFORNIA
NEW YORK 17 • CHICAGO 2 • PITTSBURGH 2 • ATLANTA 5 • SAN FRANCISCO 4
IN CANADA: 8582 MOUNTAIN SIGHTS AVENUE, MONTREAL, P. Q.

Cottrell Precipitators	Multiclone Dust Collectors	Therm-O-Flex Hi-Temp Filters	Dualaire Reverse-Jet Filters	Turbulaire-Doyle Scrubbers	Joy Microdyne Scrubbers	Combination Units	Holo-Flite Processors	Hi-Turbiant Heaters

Process Flowsheet



Unfold

flowsheet

Key, color-producing reaction takes place in wooden, paddle-stirred coupling tank.

How to Make Azo Pigments

Lithol-rubine process yields product as powder or dispersion, typifies chemistry, technology behind azo pigments.

N. P. CHOPEY *Assistant Editor*

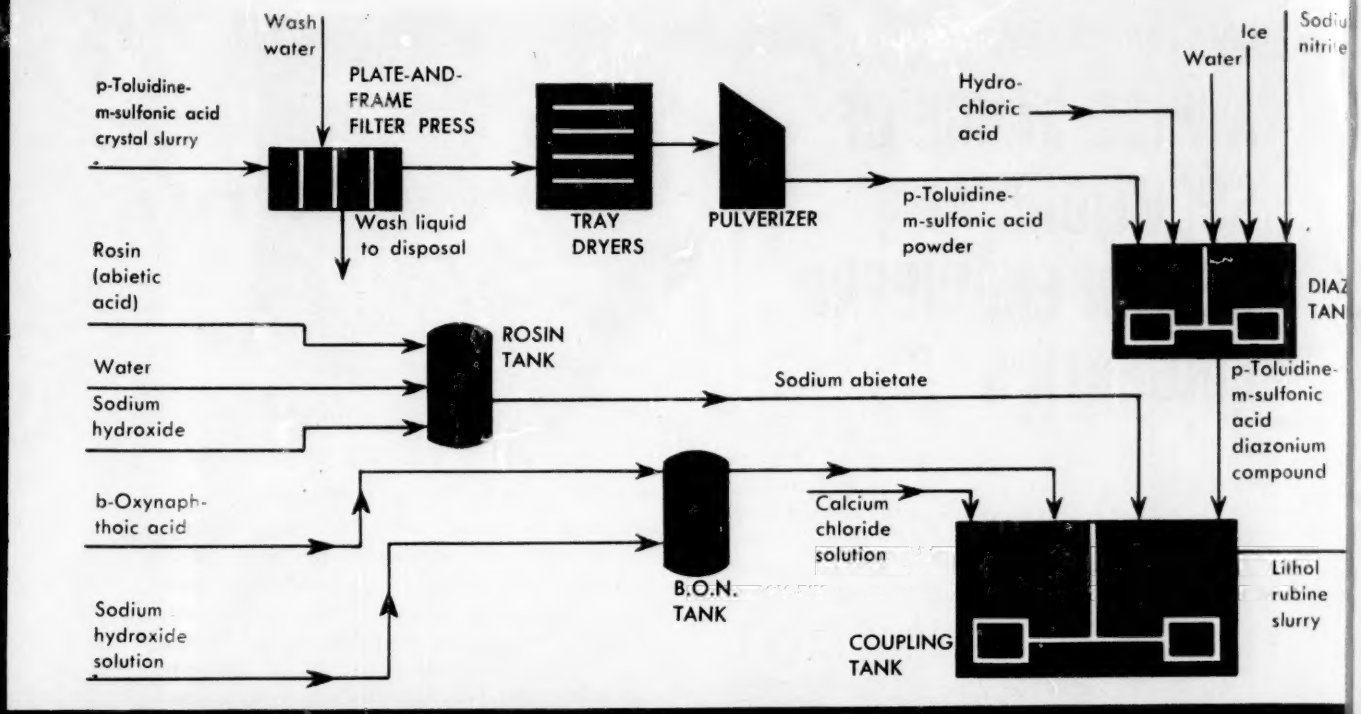
Of all the chemical process industries, perhaps the one that most universally touches everyday living is the field of pigments and dyes.

Paradoxically, though, much of this field is ranked among the more complex areas of chemical processing. This is particularly true of organic coloring substances, where an exacting technology is built around a formidable framework of chemical reactions and molecular structures.

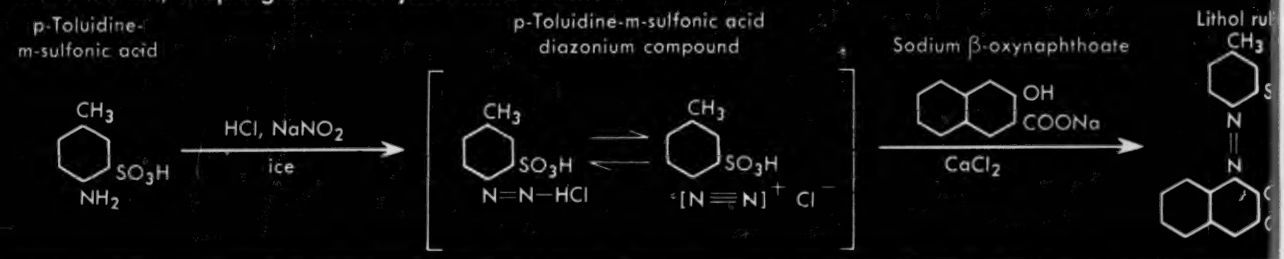
Synthetic organic pigments make up an interesting subdivision of the field. Distinction between a dye and a pigment is easily made: former is soluble in its carrier fluid and permeates the material being colored, whereas a pigment is used as an insoluble suspension or dispersion that coats the surface of the material. Pigments fall into two classes, inorganic and organic; complicated chemistry is especially a characteristic of the latter class.

A leading producer of synthetic organic pigments is the Ansbacher-Siegle Div. of Sun Chemical Corp., New York. The division's domestic operations are centered in a plant on Staten Island, New York City, where a wide variety of the coloring substances are turned out.

Plant products include dry pigments for dispersion by customers, and also finished dispersions



Diazotization, coupling reactions yield lithol rubine



in water and oils. With a few exceptions, most of the intermediates for pigment manufacture are purchased.

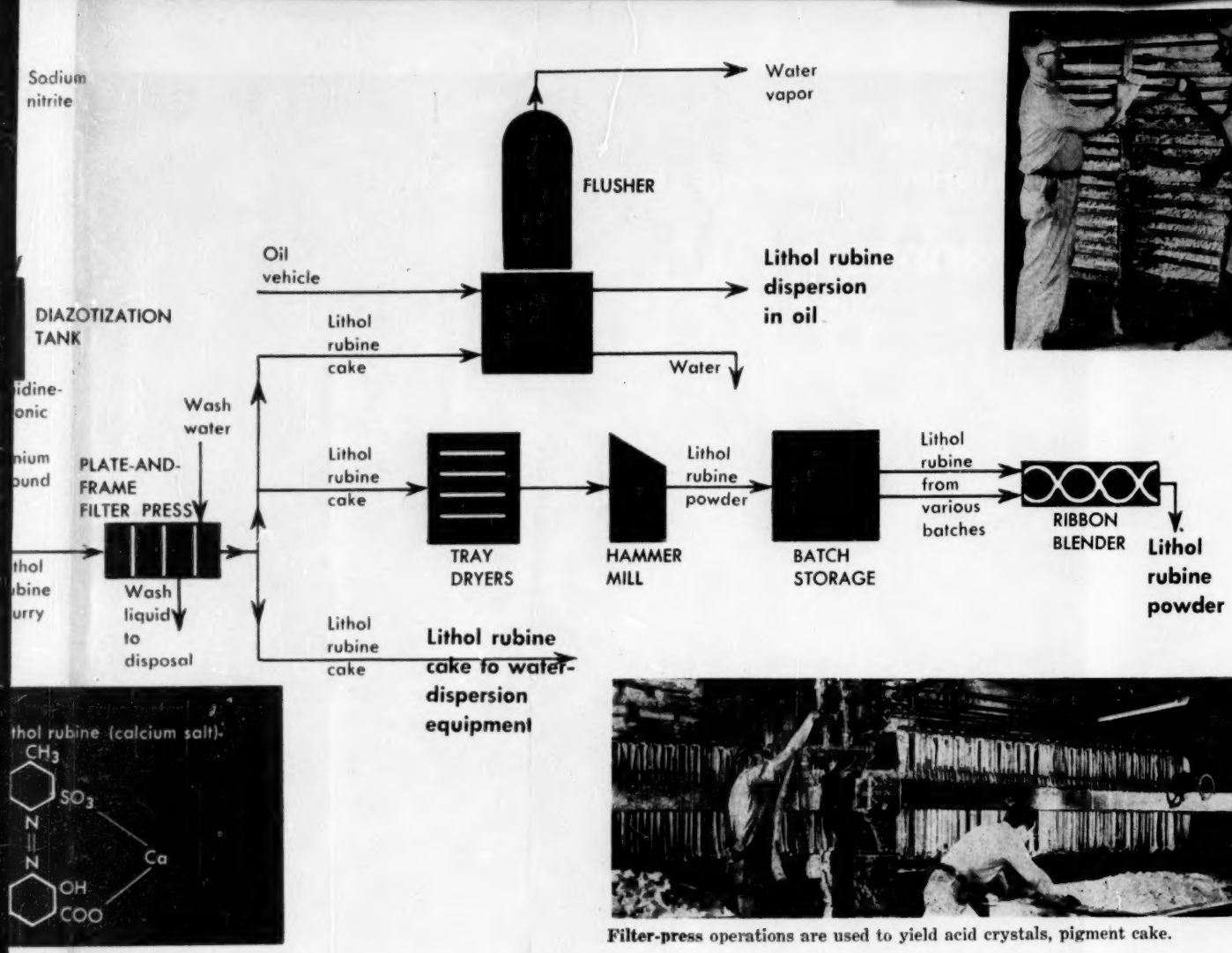
▶ **Focus on Azos**—One important category of operations at Staten Island is manufacture of azo pigments. This involves a two-step chemical sequence consisting of diazotization—attaching another nitrogen atom to the amino group of an amine molecule—followed by "striking" or coupling the resulting diazonium compound with an organic coupler. The azo pigments are often referred to as ice colors, because ice is used to maintain low temperatures during diazotization.

Coupling conditions are set so that the finished pigment contains a maximum of desirable properties, such as shade, strength and brilliance. Sometimes the coupled compound is a water-soluble dye, which must be metallized to give the properties of a pigment.

After pigment has been precipitated, it is filtered and washed, then finished either by drying and grinding to form a powder, or by dispersion in a vehicle.

A good example from the azo category is lithol rubine, a red pigment used in paints, printing inks, plastics and cosmetics. It is made by diazotizing p-toluidine-m-sulfonic acid, then coupling the diazonium compound with the sodium salt of beta-oxynaphthoic acid (see reactions, in box). Ansbacher-Siegle forms the pigment by precipitating the coupled compound as the calcium salt, then sends the precipitate to finishing steps.

Sequence used at Staten Island for making lithol rubine, shown on above flowsheet, can be broken down into three major phases. First, the p-toluidine-m-sulfonic acid (PTMS) crystals, produced at the plant by sulfonation of p-toluidine, are prepared and diazotized. Resulting compound is coupled with the sodium beta-oxynaphthoate, and coupled product is converted to pigment by



Filter-press operations are used to yield acid crystals, pigment cake.

precipitation with calcium chloride. Finally, the pigment is filtered, washed and processed to yield powder or dispersion.

▶ **First, Diazotize**—PTMS slurry from the plant's sulfonation unit goes to a plate-and-frame filter press, where the crystals are separated from mother liquor and washed. Then they are dried in tray dryers and pulverized. Resulting powder is ready to enter the diazotization tank.

Ansbacher-Siegle carries out diazotization in a paddle-stirred wooden vessel holding about 1,500 gal. Water, sodium nitrite and hydrochloric acid are also added; latter two form nitrous acid, which in turn enters into the diazotization. Reaction takes place in the presence of ice, at 32-41 F., and average residence time is about 30 min.

▶ **Next, Couple**—As preparation for the coupling step, the sodium salt of beta-oxynaphthoic acid is formed by reacting the acid with caustic solution in an agitated tank. Resulting salt solution goes to the coupling tank, a wooden vessel similar to the diazotization tank but much larger.

The diazonium compound is then added to the coupling tank, over a period of 15 min. to 1 hr. Mixture is held at 50-77 F. for 30 min. to 1 hr. Then a solution of sodium abietate, which has been prepared by combining rosin—essentially abietic acid—with caustic, is added. Function of the abietate is to adjust the shade of the pigment and to impart color strength. At this stage, a 20% calcium chloride solution is also added, to precipitate the pigment. Resulting mixture is heated to about 195 F.

Sequence of coupling operations requires about 3 hr. in all, is accompanied by constant paddle-stirring. Specific grade of lithol rubine produced is governed by many factors, such as pH in coupling tank, stirring speed, rate and temperature at which the diazonium compound is added, coupling temperature, duration and temperature of

the precipitation s
tate added.

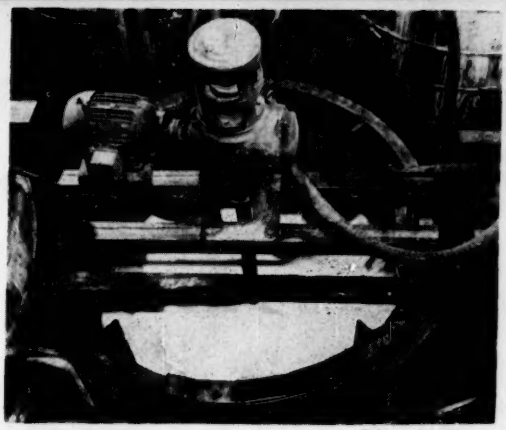
▶ **Finishing Up**—A
is completed, tank
filters where the li
as press cake and
can be sent to an
depending on the

If the pigme
cake goes to a tra
Mill yields a powd
mesh screen.

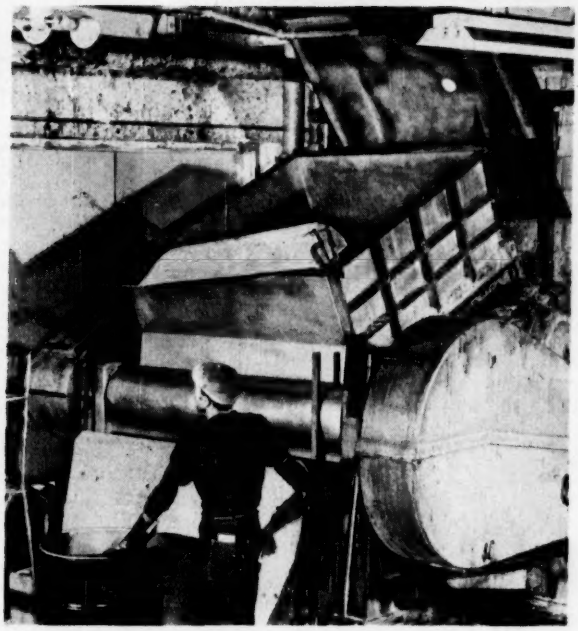
This complet
batch. To produce
ing, material fron
in a ribbon blend
blend will meet pr

If the pigmer
sion, the cake go
unit known as a

Tray dryers operate directly downstream from both filtering steps.



Diazotization tank produces diazonium compound of p-toluidine-m-sulfonic acid for coupling step.



Flusher yields oil dispersion from water-wet cake without intermediate drying.

ion step, and amount of sodium abie-

p—After coupling and precipitation tank contents go to plate-and-frame he lithol rubine pigment is separated and washed. At this point, the cake o any of three finishing operations, the end use of the product.

gment is to be sold as powder, the tray dryer and then a hammer mill. owder, 95% of which will pass a 300-

npletes the processing of a specific duce the finished powder for packag- from some five batches is combined lender in such proportions that the et product specifications.

gment is to be sold as an oil disper- e goes to a combination mixer-still s a flusher. Commercialized in the pigments industry during recent years, this unit converts the water-wet pigment into an oil-wet pigment without any intermediate drying taking place.

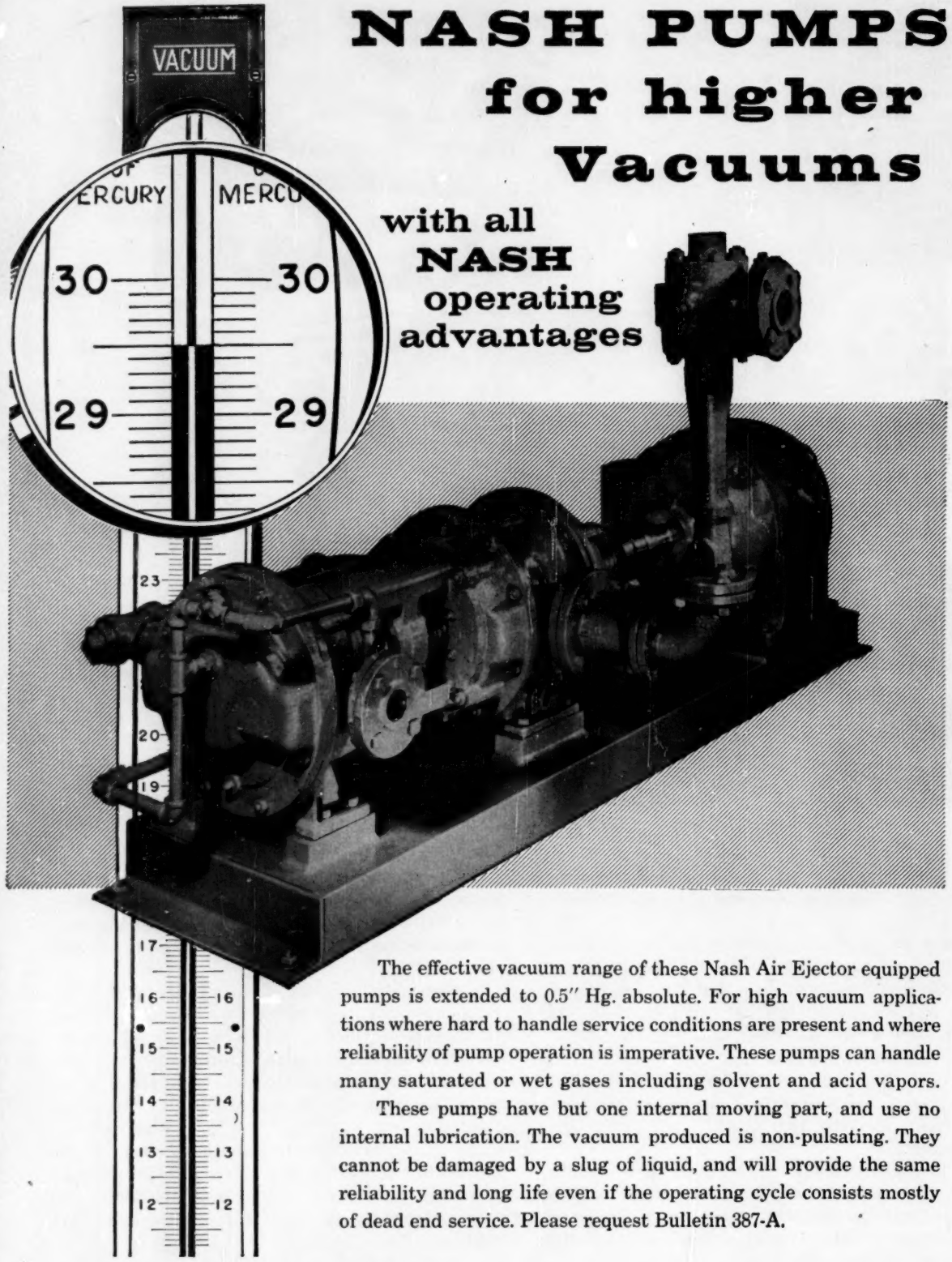
Mixer portion of the flusher is equipped with a cooling jacket and hollow, water-cooled sigma blades. The oil vehicle—which can be one of a wide variety of substances, such as linseed oil—and the water-wet cake are agitated together; result is to make the cake oil-wet and produce the finished dispersion.

Part of the separated water can be poured off by opening and tilting the mixer; the rest is removed by the still, which operates under high vacuum. Pigment dispersion is then packaged for shipment.

The third alternative, mixing the press cake in undisclosed, high-powered dispersion equipment with the aid of carefully selected agents, is used to produce water-dispersed pigments.

NASH PUMPS for higher Vacuums

with all **NASH** operating advantages

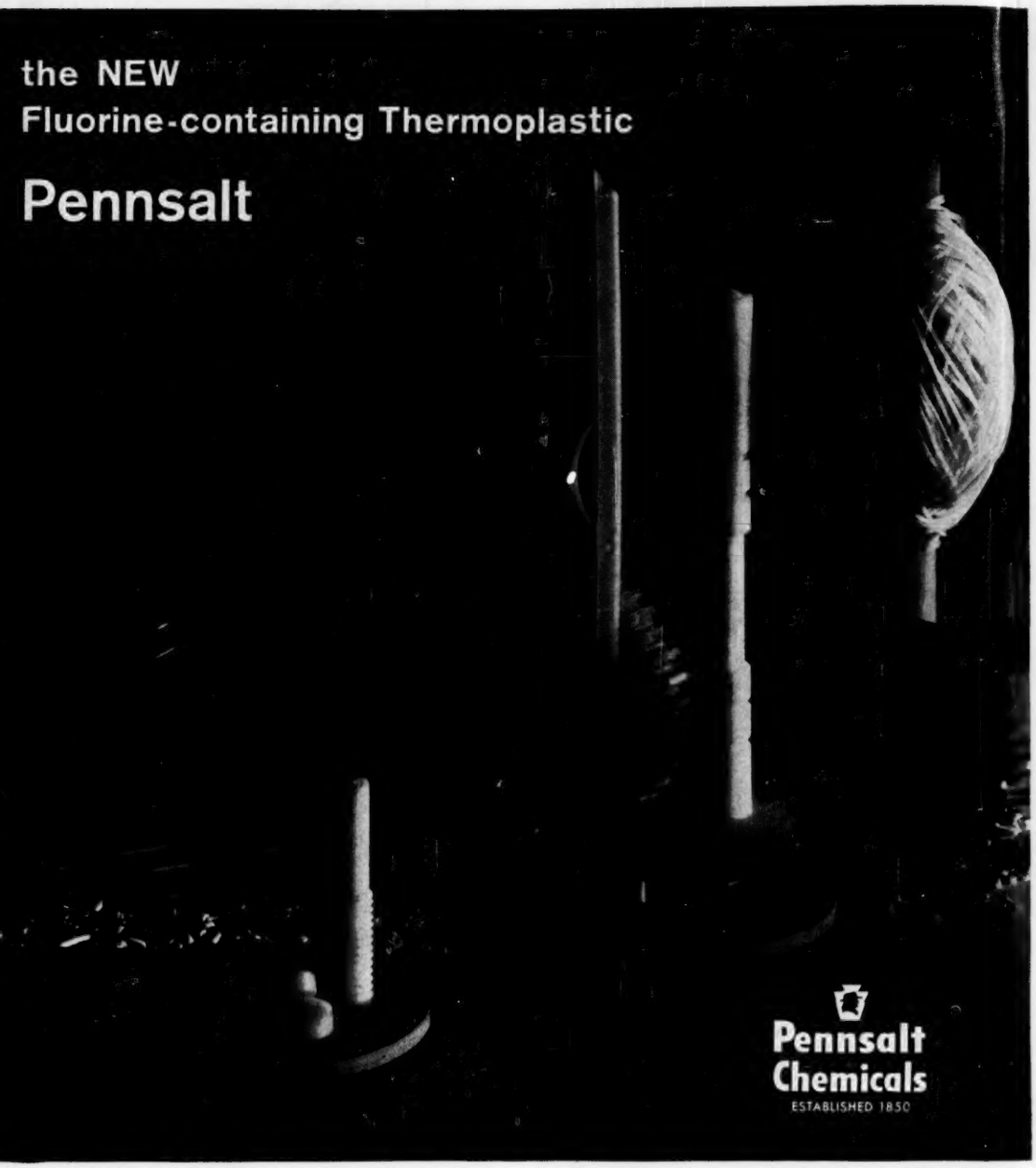


The effective vacuum range of these Nash Air Ejector equipped pumps is extended to 0.5″ Hg. absolute. For high vacuum applications where hard to handle service conditions are present and where reliability of pump operation is imperative. These pumps can handle many saturated or wet gases including solvent and acid vapors.

These pumps have but one internal moving part, and use no internal lubrication. The vacuum produced is non-pulsating. They cannot be damaged by a slug of liquid, and will provide the same reliability and long life even if the operating cycle consists mostly of dead end service. Please request Bulletin 387-A.

NASH ENGINEERING COMPANY

SOUTH NORWALK, CONNECTICUT, U. S. A.



a superior combination of key properties...

sistance to corrosive environment and wide-ranging
mperature

rength under tension, compression, impact

rmability by all standard plastic fabricating methods

additional benefits...

mensional stability—no cold flow or creep

ability to weather and ultra-violet exposure

n-flammability

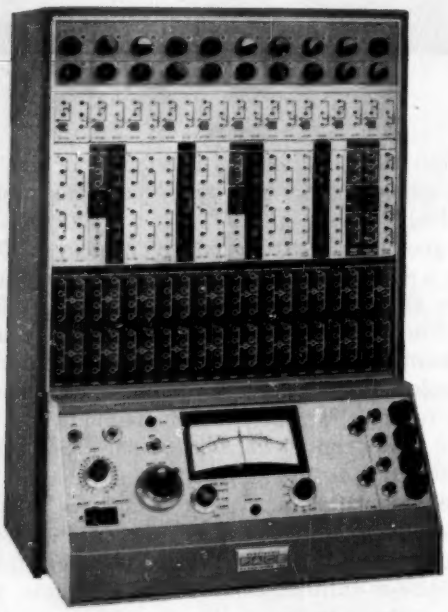
Kynar resin . . . first of a series of Pennsalt high-performance plastics . . . is a crystalline, high molecular weight polymer of vinylidene fluoride ($CH_2{=}CF_2$). It is now available in commercial quantities . . . powder and pellets . . . in grades matched to desired fabrication methods and end-product characteristics. For product information, prices, technical assistance or samples, write Research Products Development Dept., PENNSALT CHEMICALS CORPORATION, P.O. Box 4388, Philadelphia 18, Pa.

**KYNAR is a trade-mark of Pennsalt Chemicals Corp.*

EAI *Transistorized Analog Computer*

A WIDE RANGE OF SOLUTIONS AT DESIGN ENGINEERS' FINGERTIPS...

PACE® TR-10, the first all transistorized desktop analog computer, puts proven high-speed computation right where it's needed – on the desks of busy engineers. With this easy-to-use simulator, you can quickly solve many problems without waiting for scheduled access to large-computing systems. Though compact in size, the TR-10 is a full-fledged analog computer capable of providing solutions to a wide range of design problems. Up to 20 amplifiers, plus linear and non-linear computing components are contained in one compact cabinet with no external racks. The TR-10 permits rapid evaluation of different design approaches. It demonstrates the performance of a conceptual or drawing-board design prior to construction. Thus it saves time and money normally required for multiple test models with cut-and-try engineering.



Here's How The TR-10 Saves Engineering Time

The TR-10 is especially useful in solving problems in such diverse areas as servo-system design, heat flow, chemical reaction analyses, suspension systems studies and many other problems involving dynamic conditions. Fast answers to problems posed by new design ideas immediately determine feasibility of projects. With the TR-10, engineers can explore new ideas as they occur – concentrate valuable time on the most promising area of study.

(Applications notes are available describing typical problem solutions.)

How Do You Use The TR-10?

First—Represent in equation form the physical system to be studied.

Second—Select through a simple computer diagram the computing components required to perform the calculation (programming).

Third—Interconnect these components on the computer (problem patching) and set problem parameters with adjustable controls.

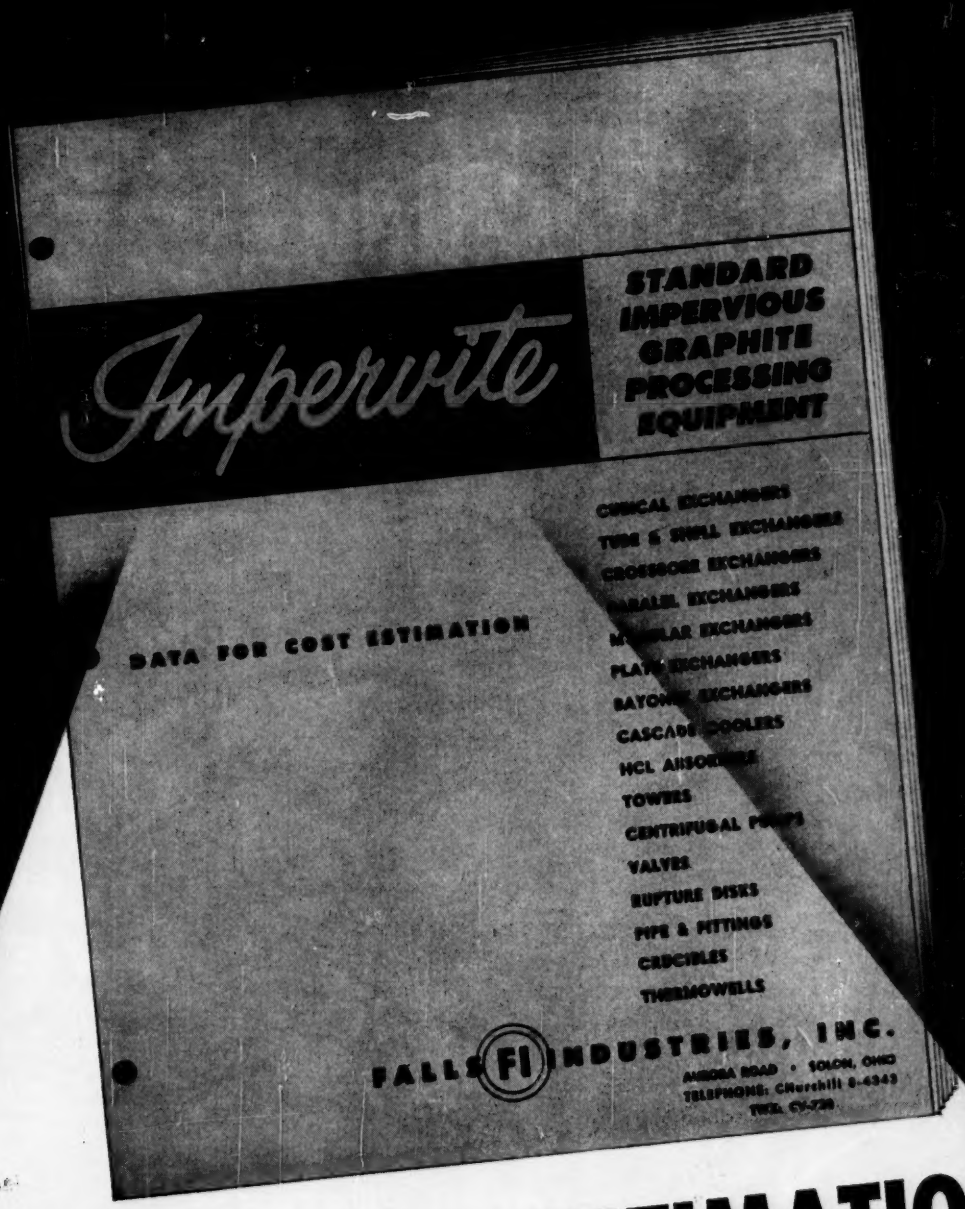
Fourth—Run the problem with results presented graphically on an accessory recorder or oscilloscope.

You now have an electronic analog *model* of the physical system under study. You can manipulate design parameters quickly, running comparative solutions without becoming involved in repeated calculations. With the TR-10 you can rapidly develop truly optimum designs.

For complete details of TR-10, write for free copy of Bulletin AC 934– EA-41.

PACE TR-10 Analog Computer, including components for addition, subtraction, multiplication, division, integration and generation of powers, roots, logs, antilogs and arbitrary functions.

EAI ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*



DATA FOR COST ESTIMATION

Falls Industries provides this 32-page report to keep busy processing people up-to-date on the latest designs and costs of impervious graphite processing equipment. Sixteen different types of equipment are covered from Hydrochloric Acid Absorbers and Cross-Bore Heat Exchangers to Rupture Disks and Thermowells. Information supplied includes standard sizes, dimensions and costs.

Because Falls Industries is so active in developing new and improved impervious graphite processing equipment, this cost and standards report is periodically revised. This present report is the third revision since this service was inaugurated. It is available on request to Engineering Department . . .

FALLS FI INDUSTRIES, Inc.

Solon, Ohio • Phone: CHurchill 8-4343

Spotlighting 2 NEW VOGT VALVES

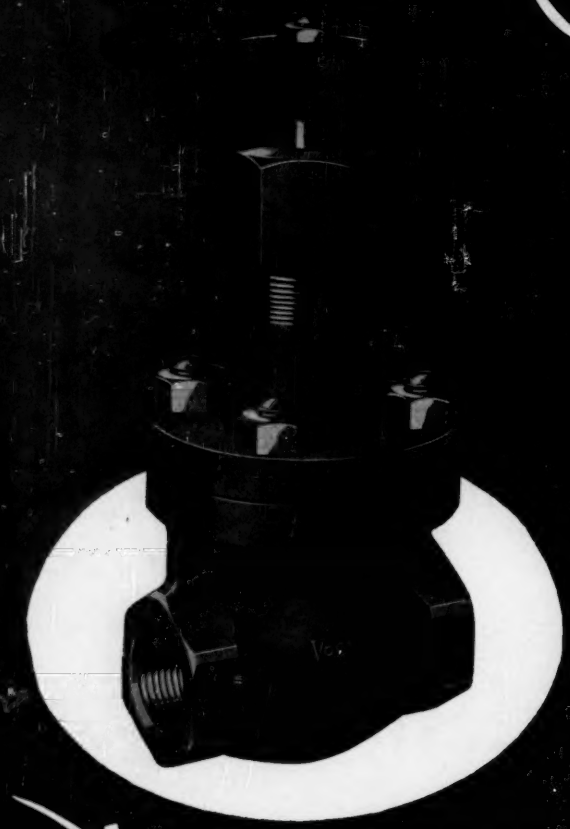
★

FORGED STEEL

INSIDE SCREW

Bolted Bonnet

GENERAL GP PURPOSE



GATE and GLOBE VALVES

150-800 Pounds Service

2000 Pounds Cold, W.O.G.

Available from stock in ¼ thru 2" sizes and in both socket weld and screw ends.

CHECK THESE FEATURES

1. Forged steel pressure containing parts designed for light weight and brute strength.
2. Hard faced seats and hardened discs and wedges.
3. Spiral wound stainless steel or Monel gaskets to suit trim.
4. Extra deep stuffing box for long packing life.
5. Dished sure-grip handwheel.

Write for literature Dept. 24A-PC

HENRY VOGT MACHINE CO., LOUISVILLE, KY.

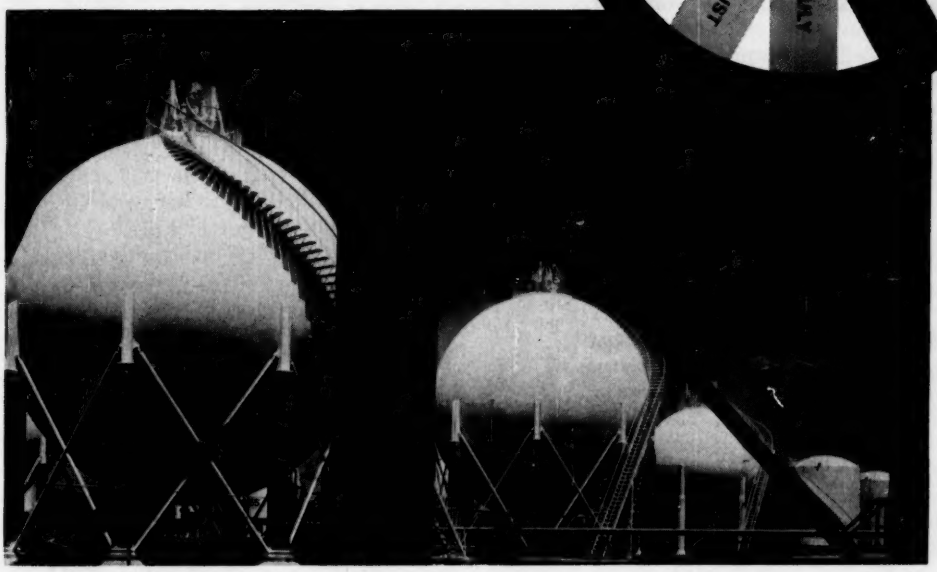
SALES OFFICES

New York, Chicago, Cleveland, Dallas, Camden, N.J., St. Louis, Charleston, W.Va., Los Angeles

Vogt GENERAL GP PURPOSE Vogt VALVES & FITTINGS

FORGED STEEL VALVES

Cloudy but Clearing: CPI Forecast for 61



As a group, the chemical process industries will move vigorously in 1961.

Despite a record $28-billion sales level predicted for chemicals and allied products in 1960, profit percentages were squeezed lower. Increased costs could not be covered by higher prices under existing competitive conditions. This year, however, forces will be working to counter the squeeze that affects not only chemicals but other chemical process industries, too.

These forces will be felt in many places: in the development of new products, in rapid construction of new plants to protect and exploit short-lived competitive leads, in cost-cutting modernization to improve profitability of older facilities, and in more imaginative marketing to open up and service new broad outlets.

In capital investment, some segments of the industry will increase their outlays over 1960. The chemicals group, for example, will spend 2% more for capital goods this year than it did in 1960; petroleum and coal products will invest 3% more (see pp. 48-50 for more of McGraw-Hill's fall survey).

What the various segments of the industry did in 1960 foretells the plans for '61. Major corporate moves, corporate realignments, new industries and new products announced in '60 set the stage for an increased level of activity. On the following pages, these developments are rounded up and projected to indicate the path of future progress.

Petrochemical Changes Abound

Big by any standard, the U. S. petrochemical industry continues to grow—and change. Opportunities seized in '60 will pay off this year.

Two major shifts joggled the pattern of activity in petrochemicals during 1960:

- Oil companies, faced with unfavorable marketing and profit prospects for petroleum products, stepped up their active participation in manufacturing and marketing of petrochemicals.
- Petrochemicals producers moved strongly toward increased production of aromatic chemicals (coal chemicals), filling a void created by the prolonged steel strike and recent low operating level.

As reported by *Chemical Week* (Oct. 15, 1960, pp. 47-50), petroleum companies are actually recasting their corporate structures in favor of chemicals by:

- Joint ventures with either chemical companies or other petroleum companies to exploit petrochemicals.
- Expansion of existing corporate petrochemical divisions.
- Formation of subsidiary or autonomous companies as full-fledged manufacturers and marketers of petrochemicals.

Out of these basic changes are coming projects that include several specifically in the aromatics field. For example, seven new petrobenzene plants will be coming on stream between late '60 and early '62; five more have been proposed. Three petronaphthalene plants are slated to start up in '61. Most of the new petrochemical benzene and naphthalene will be produced by hydrodealkylation of toluene, xylenes and alkyl naphthalenes.

The shortage of naphthalene is also causing an upsurge of *o*-xylene capacity, since *o*-xylene is an alternate starting material for phthalic anhydride. Joining the one plant already on stream will be three more between late '60 and late '61.

With the stepped-up activity in chemicals by oil companies has come keener competition. Phillips Chemical Co., long the leading manufacturer of cyclohexane, now faces major competition from two new plants operated by Gulf Oil at Port Arthur, Tex., and Continental Oil at Ponca City, Okla.

Late in the year, there was considerable conjecture that Humble Oil was about to start a petrochemical complex on a 22,824-acre tract, 10 mi. southeast of Houston. Speculation about Humble's plans was set off when the company purchased a 3-mi. strip of land giving access to Galveston Bay and the Houston Ship Channel. If Humble should start actively promoting the site to chemical companies, it will come into competition with Phillips and Socony Mobil, located at nearby Houston and Beaumont.

Another huge petrochemical complex may be in the offing on the Gulf Coast where Monsanto has a 3,000-acre site under option at Alvin, 25 mi. from Texas City. Sparked by the activity of railroad, pipeline and waterway survey teams, speculation centers on a range of end products that include ethylene, phenol, styrene, phthalic anhydride and ammonia.

While the big oil companies such as Gulf and Humble have not yet moved into styrene production, smaller Ashland Oil and Sunray Midcontinent have entered this field. And Sinclair Oil has joined with Koppers to produce styrene near Houston.

Although corporate activity dominated 1960, it by no means excluded process developments from the news columns. During the year, cryogenic techniques came into play, purifying methane prior to chlorination and thereby eliminating processing troubles arising from impurities. Boosters of methane-based acetylene have been heartened by the announcement that Diamond Alkali will use the Montecatini acetylene process in a new plant near Houston.

Also in that area, Petro-Tex Chemical will be on stream in mid-'61 with a new maleic anhydride process that uses a low-cost C_4 feedstream, rather than the more expensive benzene, and obtains 40% higher yield.

In England, Distillers Co. made headlines with a report that its $5.6-million acetic acid plant, due on stream in '62, will use a unique one-step oxidation of a light petroleum fraction, departing from the conventional two-step route via acetaldehyde.

Among leading new processes being discussed for possible commercialization were direct oxidation of benzene to phenol via a Scientific Design scheme; production of carbon bisulfide from gas oil or fuel oil, according to a flowsheet evolved by C. M. Thacker of Taylor Fibre Co., inventor of the original methane-based CS_2 process.

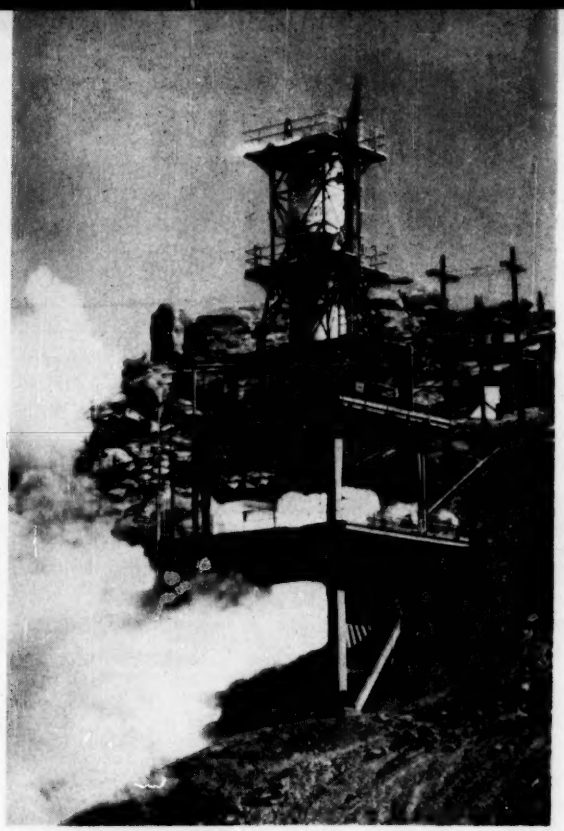
Energy Needs Keep Fuels Lively

In all forms, fuels are participating in technological changes that spell new opportunities for future growth of markets and profits.

Whether searching for new markets in prosaic earthbound uses, or seeking out ways to exploit space-age needs, fuels experts penetrated new areas in 1960.

The same upward surge of change that has swept oxygen into its key role in steelmaking has now drawn oil and gas into the act. Realizing that some of the coke charged to blast furnaces is consumed merely in heating, several plants are now injecting either oil or gas to cut coke consumption.

While coal producers may suffer cutbacks from such a reduction in coke consumption, they are taking some steps forward, too. In West Virginia, Pitt-Consol has joined forces with Texas Eastern Transmission Co. to pipeline coal to the East Coast. Project is a logical followup to Pitt-Consol's Ohio pipeline that now supplies coal to a power plant at East Lake, will incor-



Rocketdyne puts on a static test of a guided missile engine at Propulsion Field Laboratory in Santa Susana Mts.

porate some new advances in pipelining techniques.

Although there is currently a surfeit of crude oil, producers of this basic energy source and raw material are not relaxing their efforts. One unique venture is the continuing program aimed at unlocking the vast hydrocarbon potential in the Athabasca oil sands of Canada. Cities Service's pilot project in this region is now in its second year.

In Texas, several new gas-treating plants are converting natural gas with a high CO_2 content to marketable fuel. The Oil Recovery Corp., in a new venture, will liquefy CO_2 from one of these treating plants for use in secondary recovery of oil. Dissolved in water, the CO_2 provides greater oil recovery and does it faster than conventional water flooding, according to Orco.

To satisfy the exacting fuel requirements for air and space use, engineers have achieved some noteworthy triumphs. A new binder developed by Rocketdyne Div. of North American Aviation improves the prospects of making a solid fuel with 1-million-lb. thrust. Through careful control of synthesis, Rocketdyne obtains symmetrical molecules having uniform lengths. Such a binder overcomes previous inability to reproduce fuel performance with larger solid-fuel rocket motors.

In another development, Thiokol's Reaction Motors Div. has come up with a composite propellant system that employs a solid fuel with a liquid oxidizer. Details have not been revealed. But the system permits throttling over full-thrust range in flight. And it can be shut off and restarted.

For ramjet engines, Atlantic Research Corp. is working with slurry fuels consisting of an organic liquid fuel and a solid oxidizer. Such slurries contain more fuel per unit volume and, unlike solids, can be throttled by controlled pumping.

During the year, choice of fuel for the Titan II ICBM missile shifted to a hydrazine-unsymmetrical dimethylhydrazine fuel and nitrogen tetroxide oxidizer. While Olin Mathieson won a $25-million contract to supply the hydrazine, considerable interest focused on a new route to it, proposed by Aerojet-General Nucleonics. Using a nuclear reactor, Aerojet would contact uranium dioxide directly with liquid anhydrous ammonia at moderate temperature and sufficient pressure to keep the ammonia liquefied. Cost might be only one fourth that of the current ammonia-caustic-chlorine route.

Conversion of fuels directly to electric power via the fuel cell continued to attract major effort. General Electric announced a new solid-electrolyte cell, aimed at military usage. Later in the year, Shell disclosed that its new fuel cell had a radically different electrode that is claimed to give the cell three to five times more power per unit volume than competitive low-temperature cells. And the electrodes are cheap and easy to fabricate.

Outstanding among nuclear fuel developments is an impervious coating of alumina applied to tiny beads of uranium dioxide to confine all fission products within the beads.

To Metal Organics, Now Add TML

Tetramethyl lead has entered the antiknock lists against tetraethyl lead and may take half the gasoline market within the next five years.

Probably the most significant news in metal organics in recent years was the commercialization last year of tetramethyl lead as a competitor of tetraethyl lead. Long the leading method of raising the antiknock value of gasolines, TEL addition has come pretty close to a practical limit, although still below the legal limit of 3 cc./gal. of gasoline. TML—"methyl" as the industry is calling it—contains about 15% more lead per unit of weight.

Although more expensive than TEL, TML is slightly more effective in raising octane quality on an equivalent lead basis and thereby becomes both a more effective and a more economical antiknock agent for the high-octane, highly aromatic gasolines produced by catalytic reforming for today's high-compression automobile engines.

California Standard was the first oil firm to introduce "methyl gas," followed shortly by Mobil Oil. The material is being made by Ethyl Corp. and by Du Pont, while Houston Chemicals has plans to make both TEL and TML. (This last is a subsidiary of

Philadelphia & Reading and Chatham Chemical. Its plant is to be situated adjacent to Mobil Oil's Beaumont, Tex., refinery.) Ethyl is making TML in a new $330,000 facility at Baton Rouge; Du Pont at Deepwater, N. J. Within five years, the industry expects half of all U.S. gasoline to contain TML, with all European gasoline to be so blended as early as 1963.

Although TEL requirements in the U.S. have grown to nearly 500 million lb./year since this gasoline additive was introduced almost 40 years ago, alternate methods of octane improvement have reduced its rate of increase. Accelerating acceptance of the compact cars, with their reduced demand both for "octane" and gallons, is having its effect. So, too, is the grudging partial acceptance, by the motor builders, of the public demand for motors that will run on "regular gas." Add to all these the new competition from TML and it becomes evident that the older material is in for rough sledding.

Principal factors in the manufacture of methyl will be, of course, the same as those engaged in making ethyl fluid. The makers, therefore, are likely to lose out only insofar as the use of antiknock additives may drop. Per capita fuel consumption in transportation is certainly not likely to decrease, so the only real threat to such additives seems to lie in the types of motive power that the future may bring. Such a change—from piston engine to gas turbine—has already made wide inroads in the aviation field. Since the aircraft jet uses a kerosene-type fuel in which antiknock agents are of no value, there has already been a considerable drop in TEL use for aviation gasoline, perhaps as much as 20% since '58.

Whether the same sort of change will take place in automotive power is open to question. At present, there are only a few gas-turbine-operated automobiles in existence. It is rather widely predicted that commercial models will be on the road by '65 but there are still many problems of cost, efficiency and economy to be solved before the piston engine can be displaced in significant numbers.

Metal organics' biggest market is at the gas pump; soon, TML will be making a serious bid for TEL's place in fuel.

Nylon Gains in Tire-Cord Fray

Rayon cord, called Tyrex by leading viscose makers, still has bulk of tire-cord market, but tip-off is that nylon capacity is expanding rapidly.

Predictions of the demise of rayon as the premier tire-cord material haven't been borne out yet but the competition between high-strength viscose rayon cord (Tyrex, according to the name adopted in 1958 by a group of five leading viscose tire-cord makers) and nylon 6 and 6-6 is waxing heavier and heavier. Rayon got a reprieve this year when the automobile industry again adopted Tyrex cord tires as original equipment on almost all '61 cars. This means something like $100 million in rayon cord for '61 original equipment alone —about a third of the market. And rayon still accounts for the bulk of the remaining market.

However, nylon makers are betting that this situation will change. For the first time, late in '59, nylon-tire-cord prices fell below $1/lb., to the range of 97¢-$1.04, depending on denier and grade. Viscose-cord prices followed suit to preserve about the same differential vs. nylon as before, ending up at 57-62¢. Then, at mid-year, rayon lopped off another 2½¢ and nylon producers retaliated with a 2-5¢/lb. reduction.

From a competitive standpoint, the significant thing here is that viscose prices are probably much closer to the irreducible minimum than nylon. Du Pont, for example, has been quoted as stating that its amplified Richmond nylon facilities will employ a new low-cost manufacturing process to produce a superior grade of tire cord.

Nylon-tire-cord producers have been substantially adding to their capacity. Du Pont is more than doubling its capacity for tire and industrial yarns at Richmond. Allied Chemical is tripling its production. Dow, Chemstrand and Enka are all adding capacity.

Meanwhile, rayon and nylon may not be the only fibers in the tire-cord fray. Du Pont has developed and Goodyear has been testing a new high-temperature polyamide tire cord called HT-1 that melts at 600 F., compared with 482 F. for nylon. Air Reduction Chemical Co. is planning to introduce two polyvinyl alcohol fibers developed and now being made in Japan by Kurashiki Rayon Co. The fiber that Airco will designate as Vinal FO is a nonacetylated PVA fiber with

Although most tires will never face such service as this, nylon tire cord's superiority claims are getting attention.

properties said to make it a good tire-cord possibility. Airco Vinal 5F is a wet-spun acetylated PVA fiber that is being turned out in Japan for industrial uses such as fish nets and belting, as well as for clothing.

Of course, tire cord represents only about a third of the synthetic fibers picture. In recent years, the competitive situation over-all has been characterized by the gradual overtaking of the cellulosics by the pure synthetics. Today, the rayons account for some 40% of the total and nylon for nearly 35%. The acrylics and modified acrylics have lifted themselves to about 15%, the other small fibers to about 10%. In the face of this situation, rayon manufacturers have been turning to other fibers, if they were not already producing them, and have been coming up with improved types of rayon, such as the polynosic or high-wet-modulus cellulose fibers. For example, Hartford Fibers is commencing operation on Zantrel, a polynosic previously imported from France. Courtaulds (Ala.) is starting production on Moynel, and American Viscose on Fiber 40, both fibers of this type. American Enka's Fiber 500, also a high-modulus type, is still experimental.

The acrylics, which first appeared on the market a decade ago, now hold close to 15% of the market and may well go to 20% in the course of the next five years. Of the six producers, Du Pont accounts for two thirds and Chemstrand for a quarter of present production. Union Carbide and Tennessee Eastman both have small plants for modified acrylics while American Cyanamid and Dow, both newcomers in this field, have somewhat larger plants that, although still operated at low rates, together add up to perhaps 20% of total capacity. Producers today have about 40% more capacity than they can use but some further increase before 1965 is already being talked about.

Except in the field of sweaters, the present big use, the acrylics have tended toward non-apparel applications such as rugs and blankets. Additional increases will most probably depend on ability to increase sales in apparel, now being promoted strenuously.

One important factor for synthetic fibers' future: development of specialized types. Industry authorities seem to feel that the fibers of the next decade will be not so much new as specially designed modifications of existing fibers. Du Pont, for example, has predicted that perhaps as many as two thirds of its fiber products of five or six years hence will be improvements on —or additions to—those it is offering today.

Man Beats Tree at Own Game

With polyisoprene coming in as the synthetic equivalent of natural rubber, and polybutadiene as a near equivalent,* HEVEA *has meet its match.

In the making, right now, is what should probably be considered the most important change in the course of the rubber industry since GR-S became the order of the day, back in the War years. Two new synthetic rubbers that are, respectively, identical with and substantially the equivalent of natural rubber are coming into the picture. Their capacity today is only a few thousand tons per year, but this will change quickly, with some 200,000 annual long tons capacity projected for 1962. The new rubbers are, in turn, polyisoprene and polybutadiene or, more properly, *cis*-1,4 polyisoprene and *cis*-1,4 polybutadiene.

World consumption of natural rubber is currently at the rate of about 1.9 million long tons, with the prospect that supply will shortly level off at an inflexible 2 to 2.3 million tons. Of the total, present U. S. consumption of natural rubber is about 520,000 long tons, which is close to one third of the U. S. combined total of natural plus synthetic. Elsewhere in the world, natural rubber is about 70% of the total, rather than 33% as in the U. S.

Although we have our special-purpose rubbers such as Neoprene, butyl, nitrile, Thiokol and the silicone rubbers, the preponderance of rubber needs has been met with the general-purpose synthetic SBR—the descendant of GR-S—or with the natural product. (It has proved impossible to substitute SBR completely for natural, largely because of the heat-dissipation problem in large tires.) *Chemical Week* estimates some 220,000 tons of natural was used in '60 in the U. S. for truck tires, to which was added an estimated

120,000 tons for bus and off-road tires, and 180,000 tons for everything else.

Why, then, substitute "synthetic natural" for "natural natural" rubber? As might be suspected, the reason is primarily economic. Natural rubber is a bad actor in the world market. In '55, when the U. S. auto industry was enjoying a boom year, natural went to 48¢/lb. During the recession of '58, its price fell to 26¢. Only recently, its price came within a fraction of a cent of the '55 high.

SBR, however, sells at 23¢ for the regular, and 19¢ for an oil-extended grade, while the probable price for polyisoprene and polybutadiene will be in the 30-35¢ range. In addition to its unpredictability, natural rubber will almost certainly trend higher in the next few years as world demand comes up against the hard fact of production limitation, due to insufficient tree replanting in recent years in politically disturbed Indonesia.

This then sets the stage for the introduction of natural synthetic. Where is it to come from? At least seven companies have announced definite plans for commercialization, while others are in the exploratory stage. Shell Chemical, at Torrance, Calif., went on stream in October, while Phillips Petroleum was due to start commercial shipments early in January '61. Firestone Tire & Rubber expected to be operating by early '61, and Goodyear Tire & Rubber by mid-'61. Later startups, in late '61 and early '62, were scheduled for American Rubber & Chemical, Goodrich-Gulf and Texas-U. S. Chemical, with U. S. Rubber preparing to build a $2-million "pilot plant."

Most of these concerns are planning to make both polyisoprene and polybutadiene. Process facilities are said to be almost identical for the two so that either rubber can be made with only minor modification in the process setup. Most concerns at present prefer to make polybutadiene initially, because its monomer is more readily available and cheaper at present. However, polybutadiene is generally regarded as an extender for natural rubber rather than as a complete replacement.

Much work has been devoted to the development of low-cost isoprene monomer and it is being predicted that polymerization-grade isoprene will be made to sell for no more than butadiene. This may well throw the balance in favor of polyisoprene production.

A couple of other developments in the rubber picture, though less striking than the introduction of synthetic natural, are worthy of comment. One is the renaissance of butyl rubber. Until the mid-'50's, butyl went primarily into inner tubes. Then the tubeless tire was developed and butyl practically disappeared from view for several years.

Recently, however, Humble Oil & Refining Co.—the only butyl producer—has developed an all-butyl tire as well as several specialties such as butyl liquid and latex and halogenated butyl. Output has sprung back to about what it was before the tube debacle, and substantial capacity increases are under way at both the Baytown and Baton Rouge plants.

New Plastics Bid for Markets

Polyformaldehyde, already commercial, will soon be joined by others such as polyacrolein and special modifications of existing polymer families.

Probably the most rapidly expanding area in organic chemistry today is in plastics. Forty years ago, when you said Celluloid and Bakelite, you had said it all. Today, there are thousands of plastics and more coming all the time. An important aspect of this development is that they are being tailored more and more to specific applications. To an increasing extent, therefore, they are becoming more than equal to the task of replacing other materials, notably metals. And they are beginning to do this as superior materials, rather than as substitutes.

Some of the new ones now on the way include the polyformaldehydes, polyacrolein, polyspiroacetals, *trans*-polyolefins and polyoxetanes.

The first of these, polyformaldehyde, has already been commercialized, under the name of Delrin, by Du Pont who is making it in a new $40-million plant at Parkersburg, W. Va. No other U. S. firm is yet in this plastic but several abroad, including Badische, Hoechst and Bayer in West Germany; Staatsmijen (Limburg) in Holland; and St. Gobain in France all are stated to be in the development stage. A highly crystalline thermoplastic, polyformaldehyde has high tensile strength, fatigue life and corrosion resistance, coupled with low moisture absorption, and it can be easily fabricated by either molding or extrusion.

Polyacrolein is claimed suited for varnishes, films and other protective materials. Though not yet commercial anywhere, it has been investigated by the German firms of Hoechst and Degussa, and both are understood to be considering plants. Various U. S. firms have shown interest but haven't gone further.

New, special modifications of already commercialized polymer families are in the offing in at least three distinct cases, including the polyspiroacetals, the *trans*-polyolefins and the polyoxetanes. Shawinigan Resins Corp. has been turning out the first of these, according to *Chemical Week*, in a pilot plant at Springfield, Mass. This resin, D-430-B, is being test-marketed at $1.15/lb., with the expectation of a revised price in the 80-90¢ range when a commercial plant is built. Shawinigan hopes the resin, produced by reacting pentaerythritol with glutaraldehyde, will become an important electrical insulation. Chemstrand, meanwhile, has been looking into a similar resin as a fiber former.

Phillips Chemical, at Bartlesville, and U. S. Rubber Co., at Baton Rouge, are both interested in the *trans*-polyolefins, *trans*-polybutadiene and *trans*-polyisoprene. These materials have properties similar to natural balata rubber, making them of interest for applications requiring extreme toughness. Examples are in golf ball covers, floor tile and belting. Both companies have semicommercial plants in operation.

Representative of the third group, the polyoxetanes, is Hercules Powder Co.'s Penton, which was introduced for corrosion and heat-resistant applications in '59. Like the polyspiroacetals, the polyoxetanes may start with pentaerythritol, although development work at Purdue has also led to a process for making these materials from 1,3-diols. Research Corp. holds the patent rights for this latter process.

Polyolefin Capacity on the Rise

Despite cries of overcapacity, polyethylene plants are still being built. Meanwhile, polypropylene capacity is increasing almost explosively.

Big news last year in polyolefins was the rapid increase in plans—and capacity—for polypropylene, which is bidding to become one of the fair-haired children of the plastic age. Enthusiasts foresee three big markets: in film, molded products and filaments.

Polyethylene, however, hasn't stopped its own growth despite recent agonized cries of overexpansion. Carbide's subsidiary, Union Carbide Caribe, is building what is claimed to be the world's largest polyethylene plant, near Ponce in Puerto Rico. This will be a high-pressure plant, sized to make 110 million lb./yr., most of which will probably be marketed abroad. Goodrich-Gulf is getting into the polyolefin game with a 13-million-lb./yr. high-density polyethylene plant at Port Neches, Tex. Allied Chemical is adding some 10-15 million-lb. capacity for its low-molecular-weight polyethylene at Orange, Tex.

Polyethylene film makers have rapidly expanded capacity. Du Pont has started up a new film facility at Richmond, Va., with an annual capacity expected to reach more than 30 million lb. With its film plant at Buffalo, Du Pont will boost production potential to some 50 million lb. Rexall Drug & Chemical's Turex Plastics subsidiary, at Nasonville, R. I., is aiming at a 10-million-lb. capacity. And Rexall, teaming up with El Paso Natural Gas, is putting up a petrochemical plant in Odessa, Tex., which is to produce olefins and polyolefins. Capacity for polyethylene and polypropylene together is to total over 150 million lb./yr.

Polypropylene came into the picture commercially in 1958, at which time Hercules Powder Co. was the only operating company. At present, four more concerns including Avisun (Sun Oil plus American Viscose), Dow, Humble Oil and Novamont (a U. S. subsidiary of Montecatini) all have operating capacity. According to an estimate of *Chemical Week* (Nov. 12, 1960, p. 26) present annual capacity totals 135 million lb./yr. Three more companies, including Shell Chemical, Texas Eastman and Firestone will have operating plants by '62, while total year-end capacity in '62 is estimated at 545 million lb. Phillips Chemical also plans to build a polypropylene plant of unstated capacity.

Speculation has credited several other companies with polypropylene plans, among them Du Pont, Union Carbide and some diversification—bound oil companies.

Rosenfeld photo courtesy Owens-Corning Fiberglas

"Rhubarb," Block Island 40 yawl owned by B. B. DuPont, exemplifies large fiberglass boats now gaining favor.

Polypropylene sales were said to have totaled around 40 million lb. in '60. They should more than double in '61 and triple in '62. Industry sources expect film and sheeting to take from 40 to 55% of output, moldings 25 to 35% and fiber 15 to 25%, once markets have settled down. However, if fiber can add textile uses to its present applications in bristles, cordage, lawn furniture, this could become the largest outlet.

Its ability to form clear films that compete favorably with cellophane indicates a big future for wrapping.

The year saw a number of technical developments in the polyolefins. Lucidol Div. of Wallace & Tiernan brought out a substituted diperoxide catalyst for cross-linking high-density polyethylene to produce properties similar to those produced by irradiation. This is done, it is claimed, at considerably lower cost than by irradiation. And polyolefin plastics moved toward a close relationship with rubber through the development of ethylene-propylene copolymers, rubber-like materials with good resistance to ozone, wear and

groove cracking, that can probably be sold for less than SBR rubbers. Montecatini led the way in this development with a 20,000-ton/yr. plant being built in Brindisi, Italy. Hercules Powder and U. S. Rubber have both announced plans to follow suit.

It's significant that Ziegler catalysis, such as is involved here, seems to be erasing the traditional lines between plastic and rubber technology. Many firms now producing polymers, either on the rubber or plastics side, are also actively investigating these polyolefin copolymers.

Polycarbonates to Oust Metals?

Now made by two U. S. firms and actively studied by others, polycarbonate plastics hope to offset high prices by unique physical properties.

One of the most exciting new families of plastics is the polycarbonates, now made by General Electric at Mt. Vernon, Ind., and by Mobay Chemical Co., at New Martinsville, W. Va.

Both GE and Bayer of Germany independently developed processes for these materials. The Bayer process is represented in U. S. by Mobay, Bayer-Monsanto subsidiary. Both Carbide and Columbia-Southern are exploring this resin and process in pilot-plant studies.

GE's product, which it calls Lexan, is being made in a recently opened 5-million-lb./yr. plant, will sell at \$1.30 to \$1.75/lb. By '62, GE expects the price to be down to 90¢-\$1.20/lb., and perhaps to 60-85¢ by '65. GE's forecast of the market anticipates a rather slow start of 6-12 million lb. by '62, accelerating to 30-50 million lb. by '65 and perhaps to 100 million by '70. Some 300 commercial applications have already been proved out for these materials, due to their high-performance properties of exceptional dimensional stability, impact strength, ductility, low water absorption, and good heat resistance and electrical properties.

The polycarbonates are transparent and thermoplastic, suited to almost all forming methods, including extrusion, blow and injection molding, vacuum forming and cold forming. These materials can even be cold drawn, forged or stamped by techniques similar to those used for metals; and they won't support combustion. Unique properties are expected to offset the present rather high prices.

GE is making the resin at Mt. Vernon by reacting bisphenol-A with phosgene in the presence of pyridene and a solvent, to produce the resin plus HCl. Since there is a wide variety of polyphenols available, more than 50 different polycarbonates have been synthesized and new resin variations are being actively investigated for commercial potential.

Polycarbonates hold strong interest for the electrical, aviation, automotive and photographic industries. They can frequently replace metals and, in fact, have tensile strengths comparable to many metals. Ultimate tensile strength is about 9,000 psi. at room temperature, and 13,000 psi. at temperatures less than −60 F.

Polyesters Will Double by '63

Glass-reinforced polyesters are rapidly replacing wood in small boats, and metals in some process equipment; the foamed plastics are expanding too.

Marked increases in the consumption of many of the older plastics are still ahead. For example, the glass-reinforced polyesters and, to a much smaller extent, the epoxies, have made enormous gains on two main fronts—in boats and in corrosion-resistant process equipment. Polyester resins went into 150,000 molded fiberglass boats in the U. S. during '60—requiring around 40 million lb. of resin. Within five years, trade estimates anticipate this figure will more than double.

The use of polyesters in process equipment is by no means so dramatic at this stage. Some 2.2 million lb. were consumed in such equipment in '59. One polyester maker expects a 4.7-million-lb. market for equipment by '63 and a 15% per year increase thereafter. Prospects are considered excellent in process and storage tanks, gas scrubbers, exhaust ducts, hoods, stacks, portable storage bins and trays. Other possibilities: tank linings, filters, fans, housings, instruments cases and cooling towers.

Epoxy resins are not making as much progress in either the equipment or the boat field as was formerly expected. They account for only about 2% of the fiberglass boats at this time and probably no greater percentage of equipment applications except in reinforced glass-fiber and the epoxy cements. In the latter connection, Tex-Tube Inc., a Houston firm, is using epoxy-cemented joints in lightweight steel pipe in sizes to 4½ in. Joints withstand 800 psi. in this size, or more for smaller pipe. The company claims installation savings of as much as 25%.

One group of the older plastics, the polyurethane foams, has been forging ahead rapidly. Such foams totaled close to 100 million lb. in '60, of which 85 million was of the flexible variety, according to *Chemical Week*, and 15 million was rigid foam. Within five years, the flexible foams, used primarily for upholstery in furniture and automobiles and for mattresses, are expected to go to 200 million lb./yr., while the rigid foams may reach half that amount. The rigids are used primarily in insulation for cold rooms, ducts, transportation equipment, frozen-food-handling equipment and building panels. An increasing proportion is going into flotation material in boats and floats. A small but interesting application is as ¼ and ½-in. thick interlining material for clothing.

This rapid growth in foamed plastics has, of course, been paralleled by expansion in isocyanate capacity. Principal producers Mobay, Du Pont and Allied Chemi-

cal are all substantially increasing their capacity for this material.

While urethane foams have enjoyed this growth, polystyrene foams have not been too far behind. (They get into insulation and flotation, but not into upholstery or mattresses.) Industry prognosticators look for a possible 200-million-lb. market within five years. In the building field, an interesting competition is shaping up between urethane and styrene foams. Urethane foam is said to be a somewhat better insulator, to have higher strength and to be easier to process. On the other hand, the raw-material costs for styrene foams at present are less than for polyurethane.

New Markets Spark Aluminum

Aluminum continues to push forward in search of an even rosier future. A new direct route from bauxite to metal may speed its coming.

Aluminum forged ahead in its projected growth pattern by capturing some of the 1961 automotive market for engine metal. General Motors' new Buick and Oldsmobile compacts have aluminum V-8 engine blocks and heads; Pontiac offers the aluminum engine as an optional item in its version. Rambler, too, uses aluminum for its overhead-valve 6-cylinder engine.

To back up its major advance into engine construction, aluminum is finding increasing usage in other automobile parts, to bring total consumption per car to an average of 62 lb. in '61.

Around the world, evidence of the metal's steady penetration into new markets is found in the part that U. S. companies are playing in constructing production capacity.

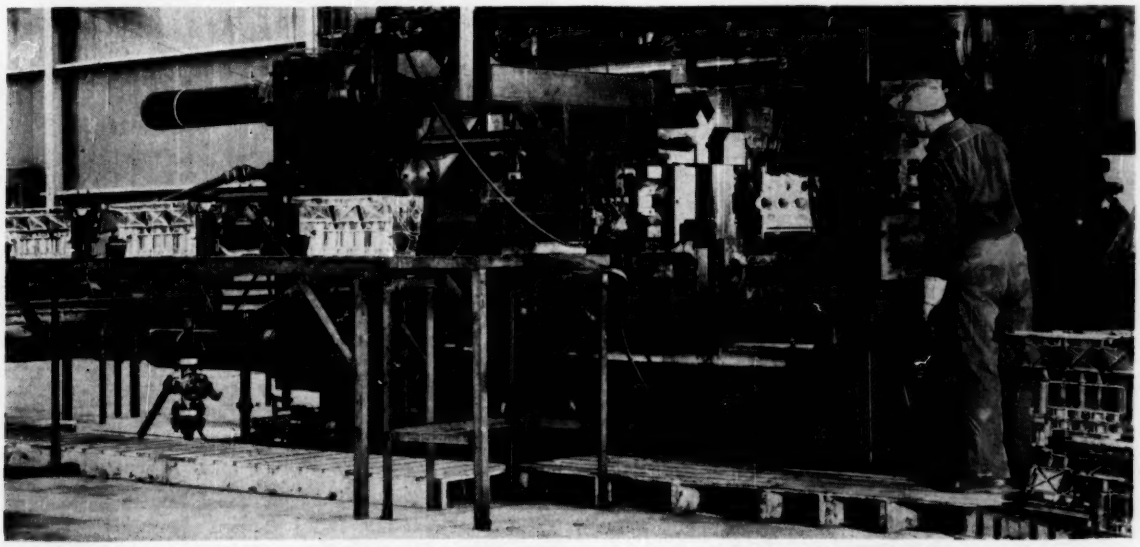
For example, Alcoa is participating with Aluminio S. A., in erection of a $20-million smelter in Veracruz, Mexico, and is partner in a $1.8-million extrusion plant going up in Venezuela. Meanwhile, it is working with the government of Surinam on a $150-million project that includes a 60,000-ton aluminum smelter.

Kaiser has part ownership in a new 12,000-metric ton smelter in Spain. And it has invested in Argentina's largest aluminum fabricating plant, built this past year. A Kaiser-sponsored consortium in Ghana aims to build a $140-million reduction plant there.

Meanwhile, in the U. S., a new producer of primary aluminum, United Pacific Aluminum Corp. of Los Angeles, announced plans to contract for a $10-million reduction plant on the Columbia river at Longview, Wash.

A technical development of major significance in '60 was disclosure that both Aluminium, Ltd., and the French Pechiney-Ugine team are undertaking to bypass the present alumina-from-bauxite extraction step. Aluminium, Ltd., is proving out the process in an 8,000-ton/yr. plant in Quebec; Pechiney-Ugine is constructing a 3,000-5,000 metric ton/yr. plant. If successful, this approach will slash capital investment as well as reduce operating costs. And it could entice new producers into the field.

Some of Aluminium, Ltd.'s, process is described in British patent 846,189. Apparently, bauxite ore is reduced to metal without first removing the impurities. The impure molten mass then contacts $AlCl_3$ to form the volatile monohalide, AlCl. Condensation of this pure vapor in a shower of pure molten aluminum reverses the initial reaction, forming metallic aluminum. Aluminum chloride released by this reaction recycles back to the converter.



Rambler engine blocks are now die-cast of aluminum; compacts by Buick, Olds and Pontiac are following suit.

Rare Metals Quicken Pace

From raw-material supply to utilization, the rare-metals industry is attuned to growth and solving big problems that hold it back.

During 1960, people in the rare, light metals business kept chipping away at tough problems that have hampered extensive production and use of these materials.

Beryllium, at $50-100/lb. in lump form, still managed to set its sights on a 300,000-lb. output for '60, up from 100,000 lb. in '58 and predicted to hit 500,000 lb. in '61. Total output may grow as much as tenfold in the next few years.

Already accorded full status as a nuclear material of construction, metal may gain wider use in aircraft and missiles. Its lightness, high melting point, high thermal conductivity, heat capacity and stiffness are good selling points in this field.

Characteristically difficult to fabricate, beryllium got a substantial boost in forging and rolling development effort during the year. And both Brush Beryllium and Beryllium Corp. of America, the two U. S. producers, expanded their fabricating facilities.

Scarcity of ore stands a good chance of easing as several companies have focused efforts toward development of Utah's Topaz Mountain for the first U. S. supply of beryllium ore. Believed to hold 1-3 million tons averaging 1% BeO, these deposits may be able to supply concentrate at a lower price than that derived from foreign 0.1%-BeO ore. Realization rests on elimination of hand cobbing of ore by leaching out Be values with acid, recovering them via Beryllium Resources' Van Dronick process.

Hope for increased use of columbium and tantalum, especially in the chemical process industries, rests on the gradual spread of technological information developed in atomic energy and missile fields.

Columbium output now amounts to about 200,000 lb./yr. at ingot prices of about $50/lb. Over the next 5-8 yr., output may rise enough to bring the price down to about $8/lb. A fluidized-bed process for making metallic columbium, developed at Battelle Memorial Institute, may be able to force prices down, boost use.

Tantalum, also bearing a $50/lb. price tag, underwent a 25% price reduction by Fansteel Metallurgical during the year. However, big growth beyond the present 400,000-lb./yr. market will not occur until additional substantial price cuts take place.

Magnesium, brought to large volume during World War II, is climbing out of recent doldrums. Loss of aircraft outlets is partially compensated by missile uses. But the brightest hopes lie in automotive uses for die-cast parts.

Entry into the market of Alabama Metallurgical Co. with its new Selma, Ala., plant is expected to stimulate use because it provides an alternate source of supply, reducing fear of shortages.

Titanium looked to increased use during '60 as Titanium Metals Corp. of America unveiled a new process for welding titanium to carbon steels. As a result of this technique, TMCA believes that titanium linings now can compete with brick- and rubber-membrane linings for vessels on corrosive service.

In the missile field, titanium was reported to be replacing steel in construction of the frame of the submarine-borne Polaris.

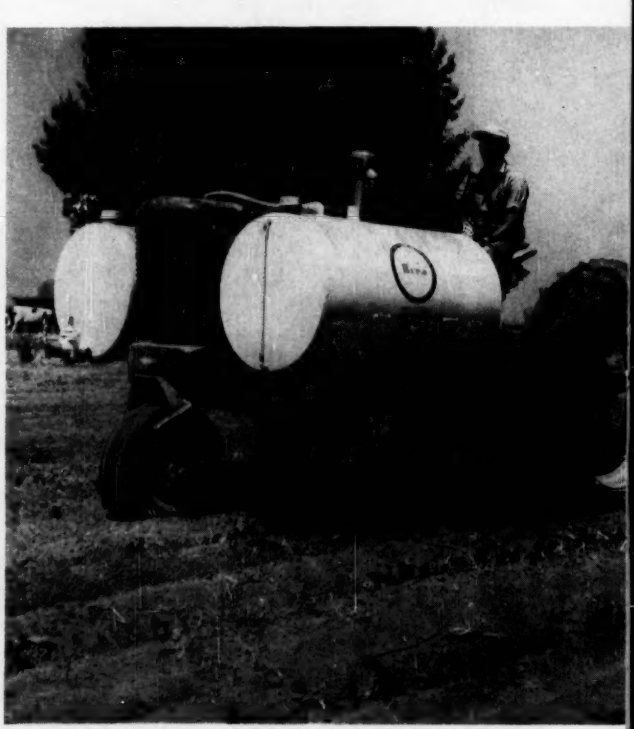
Fertilizers Stimulate Growth

Opportunities continue to lure fertilizer companies into further ventures. A new potash mine tops developments, offering a major new source.

On several fronts, fertilizer makers moved ahead in 1960.

Total ammonia capacity, for example, approached 5.2 million tons/yr. One source rates value of production from this capacity at $350 million, an estimated $50 million more than sulfuric acid. This is enough to indicate that ammonia soon may be the largest dollar-volume chemical produced in the U. S., thereby making it an indicator of the state of the economy.

A major change is shaping up in the supply of potash. With world demand for K_2O rising at the rate of



As ammonia moves toward position of greatest dollar volume among chemicals, farmers plow in aqua fertilizer.

350,000-600,000 tons/yr., Texas Gulf Sulphur decided early in November to exercise an option on potash reserves at Cane Creek, Utah, that will make it one of the two largest potash producers in North America. Mine and plant proposed for the site will turn out more than 1 million tons/yr. of potassium chloride (700,000 tons of K_2O equivalent) and will likely be on stream sometime in '64.

The TGS installation will have some 20% greater output than the next largest U. S. plant and will open up an entirely new producing area.

A potash deposit being opened up in Saskatchewan, Can., by two producers now operating at Carlsbad, N. M., is not yet producing any appreciable amounts of ore.

With a $7-million plant due on stream at Vicksburg, Miss., in October '61, Southwest Potash Co. has come up with a new way to make production of potassium nitrate a large-volume, low-cost operation. Until now, high price prevented extensive use of this material in fertilizers.

During the year, growth in capacity for phosphoric acid and phosphate fertilizer proceeded at a breathless pace. While considerable demand pressure was evident, as farmers sought to drive crop production upward under reduced acreage allotments, some fertilizer producers expressed fear that expansions would produce a bad case of overcapacity.

The swing to use of superphosphoric acid (70-76%) was marked by entry into the field at Kellogg, Ida., of the Bunker Hill Co. with a process based on wet process acid rather than the more costly furnace acid. Process was developed by Collier Carbon & Chemical Corp., which will take the output for its line of fertilizers.

To boost their earnings, U. S. fertilizer makers are integrating vertically into mixing and distribution. Among these are petroleum companies that are adding phosphoric acid and potash production to the ammonia they already have and are marketing through their gas station outlets in farm areas.

Steel, Rockets Boost Gases

The present and future look good for oxygen, hydrogen and helium. Projects under way or projected will add considerable capacity.

New forces are working to expand production of industrial gases.

Despite the low operating level of the steel industry in 1960, oxygen usage did not suffer a comparable setback. That's because makers have found that oxygen-blowing in open hearth furnaces cuts cost. Facilities that are set up to use oxygen are more competitive. So, the steel mills operate these facilities at higher levels than the older units.

Now, oxygen is under study for injection into blast furnaces, along with oil or gas fuel, to raise temperature and efficiency. Potentially, over $250 million worth of new capacity is needed to supply oxygen to all blast furnaces, based on a consumption of 3,500 cu. ft./ton of metal.

To satisfy immediate demands for oxygen by the steel industry, Linde and Air Products are now building a combined total of 18 new plants, with an aggregate capacity of 5,600 tons/day.

A new push to spurting oxygen demand is coming from the government's decision early in '60 to rely on hydrogen-oxygen engines for the upper stages of the big Saturn space vehicle. Because liquid hydrogen seems slated to be the workhorse fuel for the near-term U. S. space program, oxygen quite likely will find a growing outlet as the other constituent of the rocket fuel. However, work now under way by Bell Aerosystems Co. on a hydrogen-fluorine engine could blunt oxygen's prospects in space.

Capacity of tonnage liquid hydrogen facilities climbed in '60 as Linde started operating the first privately owned plant, at Torrance, Calif. Rated at 6 tons/day, the plant initially will deliver 75% of its output to the National Aeronautics and Space Administration. However, even at startup time, it seemed probable that total output would go to NASA, in view of estimates that, sometime in '61, U. S. government demand for hydrogen would rise as high as three times total installed U. S. capacity.

The only other tonnage liquid hydrogen plant is

Visitors at Air Products plant see natural gas and oxygen produce 40 MM Btu./hr. in open-hearth burner.

the 30-ton/day Air Force plant in Palm Beach County, Fla.

Meanwhile, the government took action in still another sector of the gas business. On Sept. 13, President Eisenhower signed legislation authorizing the Dept. of the Interior to proceed with its helium conservation program starting in March '61. While immediate supply of helium has been in good shape ever since the new Bureau of Mines plant started up at Keyes, Okla., in '59, the new program will reduce present losses of helium to the atmosphere during utilization of helium-bearing natural gas.

Under the authorization, Interior will buy helium from private industry under long-term contracts, spending up to $60 million/yr. To get the program under way, Interior mailed information about it to more than 100 companies early in November. Plants built by industry will produce crude helium, to be stored by the government in its Cliffside gas field near Amarillo, Tex., for further refinement and use, as needed.

Completely within the private industry sector of gas production and utilization, production and usage of the inert gases, nitrogen and argon, continues to grow.

Nitrogen is finding wider uses such as in annealing atmospheres in steel making, space applications, electronics, chemicals and cryogenics.

Argon is going into welding, aircraft, electric lamps and electronics, rare metal production, etc. But, in the future, greater availability of helium may cut into argon's markets.

Inorganics Build Good Support

Growth in basic inorganics assures solid support for the progress of other segments of the chemical process family in the competitive era to come.

Various inorganic chemicals are still striding ahead, maintaining a strong base for expansion of other dependent chemical processes.

One growth indicator making the news during 1960: new facilities for chlorine. Early in the year, Hooker Chemical Corp. started a $10-million installation of Hoechst-Uhde mercury cells at Niagara Falls. Other projected Hooker chlorine expansions over the next few years include two involving Hooker diaphragm cells and one with mercury cells.

Later in the year, Allied Chemical's Solvay Process Div. announced a 100-ton/day expansion at its 400-ton/day Brunswick, Ga., plant. Also revealed were Olin Mathieson's plans to build a $13-million, 180-ton/day plant at Charleston, Tenn.

These expansions will add to a U. S. chlorine capacity that already totals 5.5 million tons from 61 producers. Among the reasons cited for the present round of new facilities are growing use in fluorocarbon compounds and in production of wood pulp.

Both anhydrous HF and HCl scored some noteworthy gains during the year. At Nitro, W. Va., Allied Chemical expanded its HF operation by 50%, while Dixon Chemical went ahead with plans to build a 10,000-ton/yr. HF plant at Paulsboro, N. J. Output from these plants will likely go largely into fluorocarbon materials. But in the offing looms potential demand for space propulsion needs.

Anhydrous HCl shipments rolled over the rails in tankcars for the first time under a special test permit from the Interstate Commerce Commission. The specially designed cars are rated for 600 psi., have twin shells separated by a 10-in. layer of polystyrene insulation and feature built-in liquid CO_2 cooling.

Conducted by the American Chemical Co., Watson, Calif., the tests could result in freeing large-volume users of anhydrous HCl from locating adjacent to a supplier in order to take delivery via an over-the-fence pipeline.

Sulfur demand in the U. S. over the next decade has been projected at 7.5 million tons in '65 and 9 million tons in '70, according to Gino Giusti of Texas Gulf Sulphur Co. For the entire free world, these figures become 21 and 26 million tons, respectively.

Recovery of sulfur from gas will play a key part in filling these demands. Recently, in Canada, Texas Gulf has worked with International Nickel to pilot the extraction of elemental sulfur from sulfur dioxide produced at Inco's large iron-ore recovery project.

In carbon dioxide, there is a definite trend toward production and use of the liquid form rather than the solid. By '70, solid CO_2 will have only 25% of the market in contrast to its 55% share today.

There is new activity toward development of coal mine wastes as a source of aluminum sulfate and alumina. North American Coal Corp. announced its intention to build a $1.3-million pilot plant at Powhatan, Ohio, using an aluminum sulfate process licensed from Strategic Materials Co. The company hopes the economics will favor calcination of the alum to alumina, thereby opening up a vast new source.

According to a report from Canada, Continental Titanium Corp. of Toronto has a new pressure-leaching process that produces pigment-grade TiO_2 at 30% lower cost than formerly. Plans call for construction of a $2-million plant, 60 mi. east of Quebec City.

Reprints Available

For your files, copies of this 12-page report are now available in reprint form. For fastest service just circle No. 170 on your Reader Service Card in this or any subsequent issue. Price for single copies is 50¢.

Numerical Solution of the Heat Conduction Equation

YUDELL L. LUKE, *Midwest Research Institute, Kansas City, Mo.*

Last November in Kansas City, Chemical Engineering *and Midwest Research Institute sponsored a two-day technical conference to re-emphasize the fundamental importance of chemistry, mathematics and physics in chemical engineering. It called attention to techniques based on these sciences that are beginning to find application in our field. At this conference, ten papers were presented covering The New Tools of Engineering, The New Mathematics and The New Chemistry. There were two of these papers in our Dec. 12, 1960 issue, two in Dec. 26. Three mathematics papers appear in this issue. Remaining three papers will appear in the next issue.*

Problems of heat conduction and diffusion are of considerable importance to chemical engineers and other scientific workers. As the basic mathematical equation is the same for both subjects, we will discuss only heat conduction in this paper.

There are a large number of cases where the physical problem can be idealized so that solutions are obtained in closed form. These simplified solutions usually are obtained by assuming that the thermal characteristics of the medium are independent of the temperature. Although this philosophy is mathematically convenient, the resulting data may not conform to the actual phenomena of interest, and indiscriminate use of the data may be misleading. For most phenomena arising in practice, the thermal properties are temperature dependent. Here, closed-form solutions are generally not available, and one must seek numerical methods to compose a solution. Thus, numerical analysis, the art and science of computation, is of vital interest in this field.

To obtain numbers, the automatic computer is an important tool; however, the machine must be taught. Numerical analysis is concerned with theoretical and practical development of efficient mathematical techniques for the numerical solution of applied problems. Because applied mathematics ultimately reduces to numerical data, knowledge of numerical analysis is essential. To illustrate some of its facets, we examine numerical solution of the heat conduction equation in one dimension in some detail.

For numerous closed-form solutions, the reader should consult Carslaw and Jaeger[1] and the references given there. Other important volumes pertinent to the present discussion are by Crank,[2] Dusinberre,[3] Jakob[4] and Jost.[5]

1. Solution for Constant Thermal Characteristics

The following notation is employed: V = temperature (°C.); t = time (sec.); ρ = density of medium (gm. m./cm.^{3}); c = heat capacity of medium (cal./gm. m. °C.); k = thermal conductivity of solid (cal./sec. cm. °C.); x = space coordinate (cm.); $K = k/\rho c$.

Other notation is introduced as required. For an isotropic homogeneous solid, we have the partial differential equation

$$\frac{\partial V}{\partial t} = \frac{1}{\rho c}\frac{\partial}{\partial x}\left(k\frac{\partial V}{\partial x}\right) = K\frac{\partial^2 V}{\partial x^2} + \left(\frac{\partial k}{\partial V}\right)\left(\frac{\partial V}{\partial x}\right)^2 / \rho c \qquad (1.1)$$

The solution of this equation is linear in t, but is not linear in x. Eq. (1.1) is sometimes called semilinear.

Introduce a new parameter $S(V)$ by the equation

$$S(V) = \int_0^V k(v)dv \tag{1.2}$$

Then, with $V = V(x,t)$ and $S = S(x,t)$, we have

$$\frac{\partial V}{\partial t} = \frac{1}{k(V)}\frac{\partial S}{\partial t}, \quad \frac{\partial V}{\partial x} = \frac{1}{k(V)}\frac{\partial S}{\partial x} \tag{1.3}$$

and (1.1) becomes

$$\frac{\partial S}{\partial t} = K(S)\frac{\partial^2 S}{\partial x^2} \tag{1.4}$$

Here, $K(S)$ is the diffusivity coefficient. Note that if only k is independent of temperature, the forms of (1.1) and (1.4) are identical.

We consider a semi-infinite solid, having initial and boundary values as follows:

$$\left.\begin{aligned} V(x, 0) &= 0 \text{ for all } x \\ V(0, t) &= F(t) \end{aligned}\right\} \tag{1.5}$$

where $F(t)$ is some given function. In the S notation, we have

$$\left.\begin{aligned} S(x, 0) &= 0 \text{ for all } x \\ S(0, t) &= \int_0^{F(0)} k(v)dv \end{aligned}\right\} \tag{1.6}$$

If k, ρ and c are constant, K is constant, and we denote these quantities by k_o, ρ_o, c_o and K_o, respectively. In this event, the temperature is written $T = T(x,t)$. Then

$$\left.\begin{aligned} \frac{\partial T}{\partial t} &= K_o\frac{\partial^2 T}{\partial x^2}, \\ T(x, 0) &= 0 \text{ for all } x \\ T(0, t) &= F(t) \end{aligned}\right\} \tag{1.7}$$

and it is known[1] that

$$T = \frac{2}{\pi^{1/2}}\int_a^\infty e^{-\beta} F\left(t - \frac{x^2}{4K_o u^2}\right)du \tag{1.8}$$

where $a = 1/2\ x\ (K_o\ t)^{-1}$ and $\beta = u^2$.

If $F(t)$ can be expressed in the form

$$F(t) = \sum_{n=0}^{\infty} a_n\, t^{n/2} \tag{1.9}$$

then

$$T = \sum_{n=0}^{\infty} a_n\, T_n \tag{1.10}$$

and

$$T_n = \Gamma\,(n/2 + 1)\,(4\,t)^{n/2}\, i^n \operatorname{erfc}\{\tfrac{1}{2}\,x\,(K_o\,t)^{-1/2}\} \tag{1.11}$$

Here, $\Gamma(z)$ is the gamma function and

$$\begin{aligned} \operatorname{erf}(x) &= \frac{2}{\pi^{1/2}}\int_0^x e^{-\beta}\,du \\ \operatorname{erfc}(x) &= 1 - \operatorname{erf}(x) = \frac{2}{\pi^{1/2}}\int_x^\infty e^{-\beta}\,du \\ i^0\operatorname{erfc}(x) &= \operatorname{erfc}(x) \\ i^n\operatorname{erfc}(x) &= \int_x^\infty i^{n-1}\operatorname{erfc}(u)du \end{aligned} \tag{1.12}$$

$\operatorname{erf}(x)$ is called the error function and the $i^n\operatorname{erfc}(x)$ are repeated integrals of the error function. For further discussion of these and tables, see Appendix II of Carslaw and Jaeger.[1] Tables of the repeated integrals in (1.12) are not as extensive as may be required. If we write

$$\begin{aligned} Hh_0(x) &= \int_x^\infty e^{-\beta/2}\,du \\ Hh_n(x) &= \int_x^\infty Hh_{n-1}(u)du \end{aligned} \tag{1.13}$$

then

$$i^n\operatorname{erfc}(x) = \frac{(2/\pi)^{1/2}}{2^{n/2}}\,Hh_n\,(2^{1/2}\,x) \tag{1.14}$$

and rather elaborate tables of $Hh_n(x)$ are available.[6]

Since $i^n\operatorname{erfc}(x)\big|_{x=0} = 2^{-n}/\Gamma(n/2 + 1)$, the boundary flux $f_o(t)$ is given by

$$f_0(t) = -k_0\left(\frac{\partial T}{\partial x}\right)_{x=0} = \frac{k_0}{K_0^{1/2}}\sum_{n=0}^{\infty}\frac{a_n t^{(n-1)/2}\,\Gamma\,(n/2+1)}{\Gamma\left(\dfrac{n+1}{2}\right)} \tag{1.15}$$

The total heat transfer per unit cross-sectional area, $Q_o(t)$, is given by

$$\begin{aligned} Q_0(t) &= \rho c_0\int_0^\infty T(x, t)dx \\ &= c_0\,K_0^{1/2}\sum_{n=0}^{\infty}\frac{a_n t^{(n+1)/2}\,\Gamma\,(n/2+1)}{\Gamma\left(\dfrac{n+3}{2}\right)} \end{aligned} \tag{1.16}$$

Note that if the thermal characteristics of the medium are temperature dependent, then the total heat transfer is given by

$$Q(t) = \rho\int_0^\infty c(V)\,V(x, t)dx \tag{1.17}$$

It is now helpful to give a synopsis of the material in the following sections. A rather detailed theoretical development for the numerical solution of (1.4) and (1.6) is the subject of Section 2. The system (1.1), (1.5) is briefly considered. An analysis for computation of the flux and heat transfer is given in Section 3. The results of Sections 1-3 are illustrated by a numerical example in Section 4.

2. Numerical Integration of the Heat Conduction Equation

We will study the system (1.4), (1.6) with the idea of replacing the partial derivatives by approximate finite-difference equivalents.[7-15] This leads to a system of equations that can be solved by using a step-by-step process—sometimes called a "marching process."

Let the mesh lengths in the x and t directions be denoted by Δx and Δt. Let $S_{ij} = S(i\Delta x, j\Delta t)$ where i and j are integers or zero.

Finite-difference approximations to derivatives are derived using Taylor-series expansions, which are usually infinite series. In practice, we can only use a finite number of terms. The difference between the true function and its approximate representation by a finite number of terms is known as the remainder. It is also often called the truncation error or simply the

error. Employing the finite-difference approximations

$$\frac{\partial S_{ij}}{\partial t} = \frac{S_{i,j+1} - S_{ij}}{\Delta t} + R_1(x, t) \tag{2.1}$$

$$\frac{\partial^2 S_{ij}}{\partial x^2} = \frac{S_{i+1,j} - 2S_{ij} + S_{i-1,j}}{(\Delta x)^2} + R_2(x, t) \tag{2.2}$$

where R_1 and R_2 are remainder terms, it can be shown (see Milne[16]) that (1.4) is equivalent to

$$S_{i,\,j+1} = r S_{i-1,\,j} + (1 - 2r) S_{ij} + r S_{i+1,\,j} + R_{ij} \tag{2.3}$$

where the nondimensional quantity r is defined by

$$r \equiv r(i\Delta x, j\Delta t) = \frac{\Delta t\, K(S_{ij})}{(\Delta x)^2} \tag{2.4}$$

Also, $R_{ij} \equiv R(i\Delta x, j\Delta t)$ is the truncation error, and

$$R(x, t) = \frac{(\Delta t)^2}{2!}\frac{\partial^2 S(x, t)}{\partial t^2} + \frac{(\Delta t)^3}{3!}\frac{\partial^3 S(x, \tau)}{\partial t^3} - \frac{2r(\Delta x)^4}{4!}\frac{\partial^4 S(x, t)}{\partial x^4} - \frac{2r(\Delta x)^6}{6!}\frac{\partial^6 S(y, t)}{\partial x^6} \tag{2.5}$$

where $x - \Delta x < y < x + \Delta x$ and $t < \tau < t + \Delta t$. If the terms that make up K are constant, the truncation error can be considerably simplified because, in this event,

$$\frac{\partial^2 S}{\partial t^2} = K_0^2 \frac{\partial^4 S}{\partial x^4}, \quad \frac{\partial^3 S}{\partial t^3} = K_0^3 \frac{\partial^6 S}{\partial x^6}, \text{ etc.} \tag{2.6}$$

If the truncation error is now notated $R_0(x,t)$, then

$$R_0(x, t) = \frac{r}{12}(\Delta x)^4 (6r - 1)\frac{\partial^4 S(x, t)}{\partial x^4} + \frac{r^2(\Delta x)^6}{6}\frac{\partial^6 S(x, \tau)}{\partial x^6} - \frac{r(\Delta x)^6}{360}\frac{\partial^6 S(y, t)}{\partial x^6} \tag{2.7}$$

We can usually minimize the error by removing the lowest order term in (2.7). Since r is a free parameter, an optimum choice in the above sense is $r = 1/6$. In this event, the first term on the right-hand side of (2.7) vanishes, and

$$R_0(x, t)\,|_{r=1/6} = \frac{(\Delta x)^6}{1{,}296}\frac{\partial^6 S(x, \tau)}{\partial x^6} - \frac{(\Delta x)^6}{2{,}160}\frac{\partial^6 S(y, t)}{\partial x^6}$$

$$|\,R_0(x, t)\,|_{r=1/6} < \frac{(\Delta x)^6}{810} N \tag{2.8}$$

where $\left|\frac{\partial^6 S}{\partial x^6}\right| < N$ in the region of integration.

The manner of composing the solution is as follows. Choose Δx and Δt. We use (2.3) repeatedly and neglect R_{ij}. When using (2.1)-(2.3) and similar type equations to compose numerical solutions, it is to be understood that the remainder or truncation terms are omitted. Now from (1.6), $S_{i,0}$ and $S_{0,j}$ are known for all i and j. Hence, (2.3) gives $S_{i,1}$ for all i. Once the $S_{i,1}$ are known, (2.3) yields $S_{i,2}$, etc.

In the solution of partial differential equations by finite difference methods, two important questions arise. They are

1. How does $|S_{in} - S(i\Delta x, n\Delta t)|$ behave as $\Delta t, \Delta x \to 0$ for a fixed value of $n\Delta t$?

2. How does $|S_{in} - S(i\Delta x, n\Delta t)|$ behave as $n \to \infty$ for fixed values of Δx and Δt?

The first item is the question of convergence. That is, does the solution of the difference equation (2.3) approach the solution of (1.4) as the mesh sizings in time and space are diminished to zero?

Now, in practice, we must select values of Δx and Δt. Thus, at each step of the process, some truncation error is introduced. Another source of error is due to "round off." This happens because, for example, in taking the product of two numbers, not all the digits can be retained, and the product is rounded. To vitiate the round-off error in itself, the usual procedure is to carry extra decimals beyond those required for final accuracy. These extra digits are known as guard units. However, there is a more serious problem in the numerical solution, and this concerns the stability of the finite-difference scheme used to approximate the partial differential equation. Suppose we have an error of some sort. The error may be due to truncation or round off, or it may arise because of a slight arithmetical mistake. What happens to this error as the finite-difference scheme is repeatedly used? If the error grows exponentially, the numerical process is said to be unstable, otherwise it is stable. Thus, item 2 above relates to the question of stability.

The answer to both questions often leads to similar conclusions on the restrictions that must be placed on the difference scheme used to approximate a partial differential equation and on the choice of mesh sizes. However, the reader must be warned that the two questions are essentially independent, and that convergence does not imply stability. For example, some workers propose replacing (2.1) by $(S_{i,j+1} - S_{i,j-1})/2\Delta t$ so as to reduce the truncation error. This idea is false economy, for it can be shown that the resulting marching process is unstable for all choices of Δx and Δt. The analyses of convergence and stability are quite involved and for the most part we spare further details. For an excellent treatment of this subject, see the volume by Richtmeyer[17] and the references given there. A book by Collatz[18] is also very valuable.

For the present study, if K_{max} is the maximum value of K under consideration, and if

$$r_{max} = K_{max}\frac{\Delta t}{(\Delta x)^2} \leq 1/2 \tag{2.9}$$

then the numerical process is convergent and stable.

We now seek an estimate of the accumulated error due to the individual truncation errors that arise at each step of the marching process. This error is notated $e(x,t)$ and is the difference of the exact solution of (1.4) and the exact solution of (2.3) with R_{ij} omitted. If r obeys (2.9), then following Milne,[16]

$$|\,e(x, t)\,| < Mt/\Delta t, \quad |\,R(x, t)\,| < M \tag{2.10}$$

Here, M is a limit for $R(x,t)$ and is independent of x and t. In particular, if the quantities that comprise K are constant and $r = 1/6$, then with e replaced by e_0, we have

$$|\,e_0(x, t)\,| < \frac{t(\Delta x)^6 N}{810\Delta t} \tag{2.11}$$

where N is given in (2.8). We can also write

$$|\,e_0(x, t)\,| < \frac{4t(\Delta t)^2}{15} P, \quad \left|\frac{\partial^3 S}{\partial t^3}\right| < P \tag{2.12}$$

If the pertinent derivatives in (2.8) have about the same value, then the factor 810 can be replaced by

3,240 in both (2.8) and (2.11). Similarly, the coefficient 4/15 in (2.12) can be replaced by 1/15.

Omitting the truncation error, a suitable finite-difference equivalent of (1.1) is

$$V_{i,\,j+1} = rV_{i-1,\,j} + (1-2r)V_{ij} + rV_{i+1,\,j} + \tfrac{1}{2}\frac{\partial k}{\partial V_{ij}}\frac{\Delta t}{(\Delta x)^2}(V_{i+1,\,j} - V_{i-1,\,j})^2/\rho c \quad (2.13)$$

where $V_{ij} = V(i\Delta x, j\Delta t)$ and the thermal coefficients are evaluated at V_{ij}. A few results for the analysis of (2.13) after the manner of those for (2.3) could be developed. However, the situation is much more difficult, owing to the presence of squared temperature terms. As (2.3) and subsequent formulas render an efficient program for numerical solution, no further discussion of (2.13) is presented, except that a numerical example illustrating (2.13) is considered in Section 4.

It must be mentioned that finite-difference schemes other than (2.3) can be derived to solve (1.4). We omit details, but see Chapter VI of Richtmeyer's[17] volume.

3. Computation of the Flux and Heat Transfer

We first consider the flux at the boundary, which we will denote by $f(t)$. Then

$$f(t) = -\left(k\frac{\partial V}{\partial x}\right)_{x=0} = -\left(\frac{\partial S}{\partial x}\right)_{x=0} \quad (3.1)$$

and so following (2.1),

$$f(t) = \frac{S_{1j} - S_{0j}}{\Delta x} + R_1(0, t) \quad (3.2)$$

Another approximation is

$$f(t) = \frac{S_{1j} - S_{-1,\,j}}{2\Delta x} + R_2(0, t) \quad (3.3)$$

where R_2 is the truncation error. Both (3.2) and (3.3) are defective in the sense that the truncation error is of larger order than that incurred in the determination of S. The accuracy using these equations will be poor, and especially so if the temperature gradient is large. Equation (3.3) seems to have a further defect in that we require the temperature at a fictitious layer away from the surface. This objection is easily overcome because a numerical value of $S_{-1,j}$ can be found using (2.3). Indeed, we later show that computation of S at one or more fictitious layers affords a convenient technique for a sufficiently accurate evaluation of the flux. Suppose then that for a given time station j, we know S_{-2j}, S_{-1j}, S_{0j}, S_{1j}, S_{2j}, etc. In the following, where no confusion will result, we simply write S_{-2}, S_{-1}, S_0, S_1, etc. Employing some coefficients given by Bickley[18],

$$\left(\frac{\partial S}{\partial x}\right)_{x=0} = \frac{\partial S_0}{\partial x} = (12\Delta x)^{-1}(S_{-2} - 8S_{-1} + 8S_1 - S_2) + \frac{1}{30}(\Delta x)^4 S^{(5)}(\xi_1) \quad (3.4)$$

where $S^{(n)}$ stands for $\partial^n S/\partial x^n$, and ξ_1 is some point in the open interval $(-2\Delta x, 2\Delta x)$. The last term in (3.4) is the truncation error. Two other differentiation formulas are

$$\frac{\partial S_0}{\partial x} = (12\Delta x)^{-1}(-3S_{-1} - 10S_0 + 18S_1 - 6S_2 + S_3) - \frac{1}{20}(\Delta x)^4 S^{(5)}(\xi_2) \quad (3.5)$$

$$\frac{\partial S_0}{\partial x} = (60\Delta x)^{-1}(3S_{-2} - 30S_{-1} - 20S_0 + 60S_1 - 15S_2 + 2S_3) - \frac{1}{60}(\Delta x)^5 S^{(6)}(\xi_3) \quad (3.6)$$

where ξ_2 and ξ_3 lie in the open intervals $(-\Delta x, 3\Delta x)$ and $(-2\Delta x, 3\Delta x)$, respectively. In the following section, we write, for example, $S^{(6)}(\xi) = S^{(6)}$, it being understood that the derivative is evaluated at some point ξ in the open interval under consideration.

Another method for computing the flux is as follows. Since the boundary time rate of change of temperature is known, $(\partial^2 S/\partial x^2)_{x=0}$ is also known from (1.4). A Taylor-series expansion yields

$$S_{ij} = S_{0j} + i(\Delta x)\frac{\partial S_{0j}}{\partial x} + i^2\frac{(\Delta x)^2}{2!}\frac{\partial^2 S_{0j}}{\partial x^2} + \frac{i^3(\Delta x)^3}{3!}\frac{\partial^3 S_{0j}}{\partial x^3} + \ldots \quad (3.7)$$

Let i take on the values 1 and 2. Neglecting the effects of the fifth and all higher derivatives, we find

$$\frac{\partial S_0}{\partial x} = (6\Delta x)^{-1}[-3S_0 + 8S_1 - S_2] - \tfrac{1}{3}(\Delta x)\frac{\partial^2 S_0}{\partial x^2} + \frac{(\Delta x)^3}{18}S^{(4)} \quad (3.8)$$

If $i = 1,2,3$, we find

$$\frac{\partial S_0}{\partial x} = (66\Delta x)^{-1}(-85S_0 + 108S_1 - 27S_2 + 4S_3) - \frac{3(\Delta x)}{11}\frac{\partial^2 S_0}{\partial x^2} - \frac{3(\Delta x)^4}{110}S^{(5)} \quad (3.9)$$

and if $i = -1,1,2$, then

$$\frac{\partial S_0}{\partial x} = (6\Delta x)^{-1}(4S_{-1} - 15S_0 + 12S_1 - S_2) - (\Delta x)\frac{\partial^2 S_0}{\partial x^2} + \frac{(\Delta x)^4}{30}S^{(5)} \quad (3.10)$$

Finally, we consider the evaluation of $Q(t)$, see (1.17). Since S is known, V can be obtained graphically or otherwise from (1.2). Then $c(V)$ is known and $Q(t)$ follows on application of an appropriate integration formula. For example, omitting remainder terms, the trapezoidal rule gives

$$Q(t) = (\Delta x)\left(\tfrac{1}{2}M_0 + \sum_{i=1}^{\infty} M_i\right)$$
$$M_i = \rho\,[c(V)V(x, t)]_{x=i\Delta x} \quad (3.11)$$

and Simpson's one-third rule yields

$$Q(t) = \tfrac{1}{3}(\Delta x)\left(M_0 + 4\sum_{i=1}^{\infty} M_{2i-1} + 2\sum_{i=1}^{\infty} M_{2i}\right) \quad (3.12)$$

4. Numerical Results

We assume a semi-infinite solid having the characteristics of SAE 1095 steel. The density is taken as independent of the temperature, and we assume $\rho =$ 7.8 gm. m./cm.^{3} The thermal conductivity and heat

capacity vary with temperature, and using well-known data, curve fits have been prepared. We take

$$\left.\begin{aligned} k(V) &= 0.178 - 0.014 \times 10^{-2}\, V \text{ (cal./sec. cm. °C.)} \\ c(V) &= 0.109 + 0.188 \times 10^{-3}\, V + 0.1983 \times 10^{-6}\, V^2 \text{ (cal./gm. m. °C.)} \end{aligned}\right\} \quad (4.1)$$

From (1.2),

$$S(V) = 0.178V - 0.7 \times 10^{-4}\, V^2 \text{ (cal./sec. cm.)} \quad (4.2)$$

For numerical work, it is convenient to express $K = k/c\rho$ as a simple and easily computed function of S. This is readily derived with the aid of a cross plot, and we find the convenient curve fit

$$K(S) = \frac{k(S)}{\rho c(S)} = 0.2094 - 0.1159S \times 10^{-2} - 0.0748S^2 \times 10^{-4} \text{ (cm.}^2\text{/sec.)} \quad (4.3)$$

The assumed boundary-temperature distribution is

$$F(t) = 9{,}600\, \tau^2 (\tau - 1)^2, \quad \tau = t \times 10 \quad (4.4)$$

In the present study, we confine our interest to the range $0 \leqq t \leqq 0.05$ sec. Thus the temperature goes from 0 to 600 C. and over this range, k and c vary considerably, see (4.1).

To gain an appreciation of the numerical procedures, we first assume constant thermal properties and compare the known closed-form solution with that obtained using the marching process. From (4.4) and (1.8)-(1.17), we have

$$T = 3.072 \times 10^5 [\tau^2 i^4 \operatorname{erfc} \theta - 24\, \tau^3 i^6 \operatorname{erfc} \theta + 192\, \tau^4 i^8 \operatorname{erfc} \theta]$$
$$= 0.768(2/\pi)^{1/2} \times 10^5 [\tau^2 H h_4(\phi) - 12\, \tau^3 H h_6(\phi) + 48\, \tau^4 H h_8(\phi)]$$

$$\theta = \tfrac{1}{2} x (K_0 t)^{-1/2}, \quad \phi = 2^{1/2}\theta \quad (4.5)$$

$$f_0 = -k_0 \left(\frac{\partial T}{\partial x}\right)_{x=0} = \frac{7.68 \times 10^4\, k_0}{(\pi K_0 t)^{1/2}} \left(\frac{1}{3}\tau^2 - \frac{4}{5}\tau^3 + \frac{16}{35}\tau^4\right) \quad (4.6)$$

$$Q_0 = \frac{1.024 \times 10^4\, \rho c_0}{21} (K_0 t/\pi)^{1/2} (21\, \tau^2 - 36\, \tau^3 + 16\, \tau^4) \quad (4.7)$$

A convenient choice for k_0 and c_0 is their respective values when $T = 300$ C., as this is a mean temperature over the boundary. Thus

$$k_0 = 0.132 \text{ cal./sec. cm. °C.}, \quad c_0 = 0.130 \text{ cal./gm. m. °C.}, \quad K_0 = 0.130 \text{ cm}^2\text{./sec.}$$

For the corresponding numerical solution, we take $r = 1/6$ and divide the time range of interest so that $\Delta t = 0.2 \times 10^{-2}$ sec. whence $\Delta x = 0.039524$ cm. It is clear from previous discussion that we can integrate in either the T or S notation. For the case of constant thermal properties, we choose the former, and using (2.3), we write

$$T_{i,\,j+1} = \tfrac{1}{6}(T_{i-1,\,j} + 4T_{ij} + T_{i+1,\,j})$$
$$T_{0j} = F(j\Delta t), \quad T_{i0} = 0, \quad i \geqq 1 \quad (4.8)$$

The initial and boundary values provide starting values and the solution is mapped by repeated use of (4.8). The first five lines of the computation are exhibited in Table I. Also recorded are parts of the 23rd, 24th and 25th lines. Note that time is directed along a column while distance is directed along a row. Thus, the 25th line gives the temperature in the x-direction at stations O, Δx, $2\Delta x$, . . . , etc., for $t = 25\Delta t = 0.05$ sec. Also recorded are the corresponding values, using (4.5) for $t = 0.05$, and it is seen that the numerical solution is sufficiently accurate for engineering purposes.

To illustrate the computation, suppose we know the values along the 4th row, and we desire T_{ij} for $i = 2$, $j = 5$. Then

$$T_{25} = \tfrac{1}{6}[52.0028 + 4\,(6.9526) + 0.52977] = 13.3905$$

The value of T_{25} using (4.5) is 13.46.

We now use (2.12) to estimate the error. Rather than approximate P, we replace P by $F^{(3)}(t)$ and write

$$|\, e_0(x, t)\,| < 123t(20t - 1)$$

Now, the maximum value of the quantity on the right is 1.54, because $0 \leqq t \leqq 0.05$. The data in Table I show that the error is less than 0.2, and so our estimate is quite conservative. A fourth of our 1.54 estimate is 0.375, which is more realistic. See the remarks following (2.12).

Values of the flux at the boundary, obtained using the various methods given in Section 4, are presented in Table II. Also recorded are the exact values using (4.6). Note that each numerical method gives acceptable engineering accuracy. Over-all, (3.6) seems the best.

Computations for the total heat transfer are detailed in Table III. It is seen that Simpson's rule gives better accuracy than the trapezoidal rule, and is the preferred approach because the error is at most about ½%.

We now consider the case where the thermal coefficients are temperature dependent. Numerics are presented using both (2.3) and (2.13). The results are recorded in Tables IV and V, respectively, for the same values of Δt and Δx employed in Tables I-III.

To illustrate the calculations, suppose we want $V_{2,\,25}$; see Table IV. Now, $V_{2,\,24} = 195.101$ and for this value of the temperature

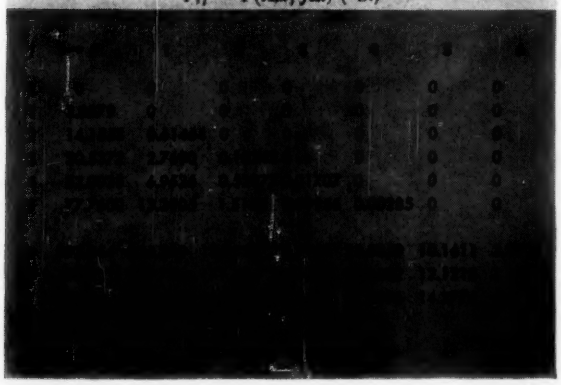
$$k = 0.1507, \quad c = 0.1169, \quad r = 0.2115$$

$$\frac{\tfrac{1}{2}\dfrac{\partial k}{\partial V}\dfrac{\Delta t}{(\Delta x)^2}}{\rho c} = -0.4914 \times 10^{-4}.$$

Numerical solution for constant thermal coefficients—Table I

$(r = 1/6, \quad \Delta t = 0.2 \times 10^{-2}, \quad \Delta x = 0.039524)$

$T_{ij} = T(i\Delta x, j\Delta t)$ (°C.)



Comparison of procedures for the boundary-temperature gradient*—Table II

$(r = 1/6, \quad \Delta t = 0.2 \times 10^{-2}, \quad \Delta x = 0.039524)$

$$-\left(\frac{\partial T}{\partial x}\right)_{x=0} \text{ (°C./cm.)}$$

	Equation Number Used					
t	(Exact) (4.6)	(3.4)	(3.5)	(3.6)	(3.8)	(3.9)
0.01	3.097	3.116	3.161	3.135	3.230	3.124
0.02	6.509	6.589	6.479	6.545	6.589	6.503
0.03	8.392	8.486	8.316	8.417	8.361	8.358
0.04	9.308	9.392	8.218	8.323	8.210	8.264
0.05	6.394	6.451	6.312	6.396	6.259	6.351

* Constant thermal coefficients

Comparison of numerical methods for the total heat transfer*—Table III

$(r = 1/6, \quad \Delta t = 0.2 \times 10^{-2}, \quad \Delta x = 0.039524)$

$$Q_0(t) = \rho c_0 \int_0^\infty T(x, t)dx \text{ (cal./cm.}^2\text{)}$$

	Equation Number Used		
t	(4.7) (Exact)	(3.11) (Trapezoidal Rule)	(3.12) (Simpson's Rule)
0.01	1.771	2.161	1.802
0.02	8.221	9.064	8.244
0.03	18.260	19.367	18.275
0.04	29.500	30.599	29.495
0.05	39.382	40.240	39.237

* Constant thermal coefficients

Numerical solution for the temperature V by (2.13)—Table IV

Variable Diffusivity

$(\Delta t = 0.2 \times 10^{-2}, \quad \Delta x = 0.039524)$

$V_{ij} = V(i\Delta x, j\Delta t)$ (°C.)

j	$i=0$	1	2	3	4
0	0	0	0	0	0
1	3.6879	0	0	0	0
2	14.1558	0.9879	0	0	0
3	30.5372	4.2396	0.2646	0	0
4	52.0028	10.1541	1.2579	0.0708	0
5	77.7600	18.7773	3.3168	0.3699	0.0189
⋮					
33	372.345	230.763	184.641	99.4560	50.7696
34	398.082	342.497	195.101	107.373	55.1513
35	600.000	352.853	205.008	115.137	61.5867

Numerical solution for S by (2.3)—Table V

Variable Diffusivity

$(\Delta t = 0.2 \times 10^{-2}, \quad \Delta x = 0.039524)$

$S_{ij} = S(i\Delta x, j\Delta t)$ (cal./sec. cm.)

j	$i=0$	1	2	3	4
0	0	0	0	0	0
1	0.6555	0	0	0	0
2	2.5057	0.1757	0	0	0
3	5.3704	0.7526	0.0471	0	0
4	9.0472	1.7968	0.2235	0.0126	0
5	13.4180	3.3069	0.5883	0.0658	0.0035
⋮					
33	80.8764	50.9172	30.1650	16.7758	8.7764
34	81.4194	52.4610	31.7448	18.0573	9.4004
35	81.6000	53.8116	33.2298	19.3076	10.5287

Then

$$V_{3,25} = 195.101 + (0.2115)\{107.373 - 2(195.101) + 342.497\} - (0.4914)10^{-4}(342.497 - 107.373)^2 = 205.008$$

Now, consider the evaluation of $S_{2,35}$. Since $S_{2,34} = 31.7448$, from (4.8) we get $K(S_{2,34}) = 0.1651$ and so $r = 0.2113$. Thus,

$$S_{2,35} = (0.2113)(52.4610 + 18.0573) + (0.5774)(31.7448) = 33.2298.$$

Put the above value of $V_{2,35}$ in (4.2). Then, $S_{2,35} = 33.55$. On the other hand, if $S_{2,35} = 33.230$ in (4.2), then $V_{2,35} = 202.86$. The slight difference in the values is due to the nature of the curve fits employed for k, c and K.

As in the case of constant thermal coefficients, it is of interest to examine the accumulated truncation error for variable diffusivity calculations. Bounds can be determined using the data in Table V and the equations (2.10) and (2.5). In this connection, it would appear that a convenient estimate for $\partial^2 S(x,t)/\partial t^2$ is $\partial^2 S(0,t)/\partial t^2$. For the numerics under consideration, the last can be found from (4.2) and (4.4). However, the bounds so obtained are very conservative and much too large to be of practical value.

A useful technique to estimate the error is known as the "deferred approach to the limit," first introduced by L. F. Richardson, see Hartree.[7] Let S be the exact solution of (1.4). Let S_1 be the numerical solution obtained from (2.3) for given values of Δx and Δt. It is clear that if Δx is doubled in size and Δt is quadrupled in size, then for a given S, the value of r remains the same. Let S_2 signify the solution in this case. Now, from (2.10) and (2.5), we can write approximately

$$S = S_1 + b\Delta t,$$

where b is a function of the derivatives of S, as can

Numerical solution for S by (2.3)—Table VI

Variable Diffusivity

$(\Delta t = 5 \times 10^{-4}, \quad \Delta x = 0.019762)$

$S_{ij} = S(i\Delta x, j\Delta t)$ (cal./sec. cm.)

$i \rightarrow$	0	1	2	3	4	5	6	7	8
0	0	0	0	0	0	0	0	0	0
1	0.0423	0	0	0	0	0	0	0	0
2	0.1674	0.0114	0	0	0	0	0	0	0
3	0.3726	0.0501	0.0030	0	0	0	0	0	0
4	0.6555	0.1239	0.0147	0.0009	0	0	0	0	0
8	2.5057	0.8349	0.2364	0.0552	0.0099	0.0012	0	0	0
12	5.3704	2.2416	0.8457	0.2844	0.0840	0.0203	0.0048	0.0009	0
16	9.0672	4.3152	1.9101	0.7797	0.2913	0.0984	0.0300	0.0081	0.0018
20	13.4180	6.9750	3.4290	1.5840	0.6832	0.2742	0.0974	0.0303	0.0083
92	80.8764	64.4485	50.5935	39.1615	29.8821	22.4468	16.4548	12.1288	8.6923
96	81.4194	65.7168	52.1567	40.7989	31.4841	23.9032	17.8838	13.1963	9.4707
100	81.6000	66.7271	53.5234	42.2940	32.9365	25.2846	19.1907	14.2614	10.2719

Boundary flux for variable diffusivity—Table VII

(a)

$$-\left(\frac{\partial S}{\partial x}\right)_{x=0} \text{ (°C./cm.) } (\Delta t = 0.2 \times 10^{-4}, \quad \Delta x = 0.039524)$$

Equation Used

t	(3.5)	(3.8)	(3.9)	(3.10)	(3.5)*
0.01	439	445	436	430	445
0.02	858	877	865	884	891
0.03	1,050	1,076	1,064	1,100	1,169
0.04	996	1,029	1,021	1,086	1,212
0.05	736	733	745	770	724

* This column gives values of $-[k(V)\partial V/\partial x]_{x=0}$ (°C./sec.)

(b)

$$-\left(\frac{\partial S}{\partial x}\right)_{x=0} \text{ (°C./cm.) } (\Delta t = 5 \times 10^{-4}, \quad \Delta x = 0.019762)$$

Equation Used

t	(3.5)	(3.8)	(3.9)	(3.10)
0.01	428	430	428	428
0.02	857	861	858	862
0.03	1,058	1,064	1,060	1,067
0.04	1,016	1,025	1,023	1,041
0.05	771	767	771	771

be seen from (2.5). We now assume that b is essentially unchanged if Δx is replaced by $2\Delta x$ and Δt by $4\Delta t$. Then

$$S = S_2 + 4b\Delta t$$

and so

$$S = S_1 + \tfrac{1}{3}(S_1 - S_2)$$

To illustrate, we first remark that the solution in Table V is now called S_2. Parts of the solution for S_1 are presented in Table VI. Note that, for example, $j = 100$ and $i = 4$ in Table VI correspond to $j = 25$ and $i = 2$ in Table V. Suppose $t = 0.01$ and $x = 0.039524$. Then $S_1 = 3.4290$, $S_2 = 3.3069$ and $S = 3.4697$. If the latter is assumed correct, then the error in S_2 is about 4.7%. Again, for the same x, but with $t = 0.05$, $S_1 = 53.5334$, $S_2 = 53.8118$ and $S = 53.4406$. If the latter is correct, the error in S_2 is about 0.7%. Thus if two S solutions are known, we can estimate the error and derive an improved S solution without using the marching process. The basic assumption is that the derivatives are sufficiently smooth and that b is invariant for the change in mesh size.

Values of the boundary flux based on the data of Tables IV, V and VI are given in Table VII. The results in the S notation for different mesh lengths are in good agreement. Note that (3.8) and (3.9) are easy to use, as calculation of S at fictitious layers is not required. In the case of variable diffusivity, care must be exercised in computing at fictitious layers, since S, for example, may become so large that its value is outside the domain for which the polynomial approximations to the thermal coefficients are valid.

Total heat transfer for variable diffusivity—Table VIII

$$Q(t) = \rho \int_0^\infty c(V)\,V(x,t)\,dx \text{ (cal./cm.}^2\text{)}$$

(a) Values derived using data of Table V
(b) Values derived using data of Table VI
(c) Values derived using data of Table VII

t	(a)	(b)	(c)
0.01	1.810	1.841	1.853
0.02	8.627	8.403	8.674
0.03	19.857	19.378	20.007
0.04	33.082	32.283	33.354
0.05	44.174	43.124	44.530

Numerical solution for temperature and boundary flux by Eq. (2.13)*—Table IX

$(\Delta t = 0.5 \times 10^{-2}, \quad \Delta x = 0.039524)$

(a)

$V_{ij} = V(i\Delta x, j\Delta t)$ (°C.)

i \ j	0	1	2	3	4
0	0	0	0	0	0
1	3.4879	0	0	0	0
2	14.1533	0.9885	0	0	0
3	30.5372	4.2594	0.2649	0	0
4	52.0028	10.2075	1.2621	0.0783	0
5	77.7600	18.9381	3.3284	0.4117	0.0255
.					
23	592.345	356.242	204.282	110.632	56.580
24	598.082	367.432	216.212	120.196	63.000
25	600.000	380.881	228.000	130.000	70.000

* r is variable but $\partial k/\partial V = 0$

(b)

Boundary Flux Using (3.5)

t	
0.01	416
0.02	788
0.03	931
0.04	804
0.05	616

Similar data for the total heat transfer are given in Table VIII.

It has been suggested in some quarters that for simplicity one should solve (2.13) with r variable, but $\partial k/\partial V = 0$. It has been pointed out by Eyres, et al.[15] that results obtained in this manner can be seriously misleading. To check this, computed values of the temperature and boundary flux under these circumstances are presented in Table IX. Comparison of the latter with the numerics in Tables IV and VII confirms the above conclusion, and emphasizes the importance of retaining the numerically small term involving $\partial k/\partial V$.

References

1. Carslaw, H. S., and Jaeger, J. C., "Conduction of Heat in Solids," Oxford, 2nd ed., 1959.
2. Crank, J., "The Mathematics of Diffusion," Oxford, 1956.
3. Dusinberre, G. M., "Numerical Analysis of Heat Flow," McGraw-Hill, 1949.
4. Jakob, M., "Heat Transfer," Wiley, vol. 1, 1949; vol. 2, 1957.
5. Jost, W., "Diffusion in Solids, Liquids, Gases," Academic, 1952.
6. British Assn. for the Advancement of Science, Mathematical Tables, vol. 1, Cambridge, 1951.
7. Hartree, D. R., "Numerical Analysis," Oxford, 1952.
8. Hildebrand, F. B., "Introduction to Numerical Analysis," McGraw-Hill, 1956.
9. Kopal, Z., "Numerical Analysis," Wiley, 1955.
10. Milne, W. E., "Numerical Calculus," Princeton, 1949.
11. Scarborough, J. B., "Numerical Mathematical Analysis," Johns Hopkins, 1950.
12. Steffensen, J. F., "Interpolation," Chelsea, 1950.
13. Whittaker, E. T., and Robinson, G., "The Calculus of Observations," Blackie & Son, 4th ed., 1944.
14. Crandall, S. H., "Engineering Analysis," McGraw-Hill, 1956.
15. Eyres, N. R., Hartree, D. R., Ingham, J., Jackson, R., Sarjant, R. J., and Wagstaff, J. B., "The Calculation of Variable Heat Flow in Solids," Royal Soc. London Philos., Trans. Series A, 240, 1-57, 1948.
16. Milne, W. E., "Numerical Solution of Differential Equations," Wiley, 1953.
17. Richtmeyer, R. D., "Difference Methods for Initial Value Problems," Interscience, 1957.
18. Collatz, L., "Numerische Behandlung von Differentialgleichungen," Springer, 1955. This is also available in an English translation.
19. Bickley, W. G., "Formulae for Numerical Differentiation," *Math. Gazette*, 25, 19-27, 1941.

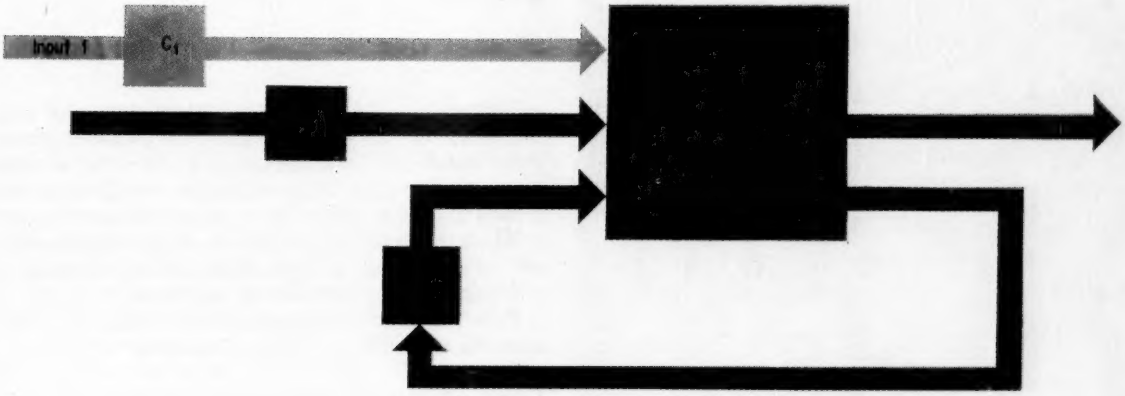
Meet the Author

YUDELL L. LUKE *is head of the Mathematical Analysis Section, Midwest Research Institute, Kansas City, Mo. He received his B.S. degree in 1939 and his M.S. degree in 1940, both in Mathematics from the U. of Illinois. Following graduation, Luke was assistant to the Dept. of Mathematics at his alma mater until the war years. After four years as a naval officer, he joined MRI in 1946.*

Mr. Luke lectures in Mathematics at the U. of Kansas and U. of Kansas City. He has also lectured at MIT.

A member of the Executive Committee of the Applied Mechanics Div., ASME, Luke serves as Sponsor for Computing Devices and Methods. He is also a member of the American Mathematical Soc., Mathematical Assn. of America, Soc. for Industrial and Applied Mathematics, Research Soc. of America, and Inst. of Aero-Space Sciences.

Mr. Luke is on the editorial board of Mathematics of Computation *and has written several important papers on numerical analysis, approximation theory, transcendental functions and aero-elasticity.*



Mathematics of Control

Application of mathematical and analytical tools to problems of process control raises an intuitive art to a quantitative science. The techniques outlined here particularly apply to distillation columns, to reactors and to problems of optimization.

THEODORE J. WILLIAMS, *Monsanto Chemical Co.*

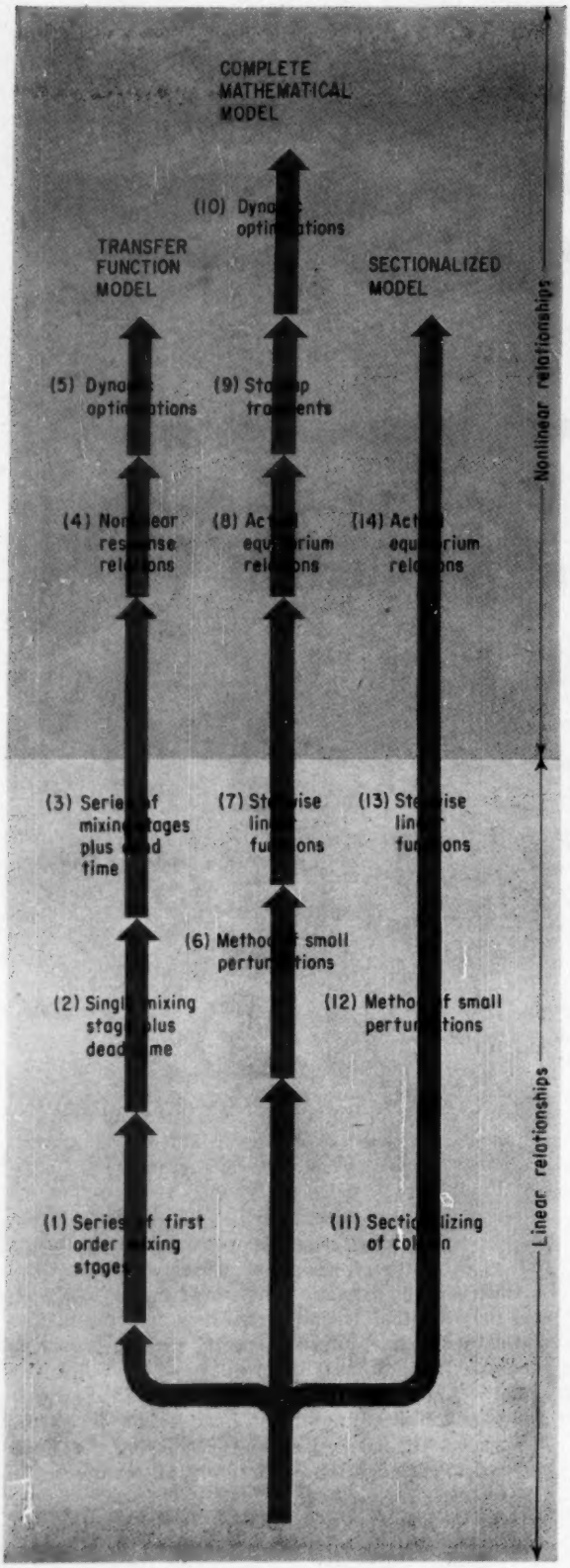
In Part 8 of the systems engineering series,[1] we listed four tasks of the control engineer. The third task—one we are concerned with here—was: by means of experimental study or theoretical analysis of the process, or both, specify required automatic control methods to be used, including the control modes and their settings, to give optimum response of the process output to upsets of each controlled variable.

In any system study, barring a purely experimental manner, it's first necessary to obtain a mathematical model of the system. This mathematical model must include a description of the proposed control scheme as well as of the process itself. It can be developed by any one of the several methods to be discussed here.

Study of the applicability of a particular control system to a process is effectively an investigation of the dynamic stability of a somewhat larger combined system, composed of the device or process being controlled and the control hardware applied. The control engineer must then prove by experimental, theoretical or computational means that, once excited, this combined system will indeed dampen out its oscillations in an optimum manner, or that when displaced from its desired operating point the system can be returned to it readily through use of the chosen control method.

Since it is the dynamic behavior of the physical system involved that is under consideration, the mathematical methods required to specify such responses by theoretical means must be ordinary or partial differential equations. Further, because of the extreme difficulty of obtaining dynamic solutions to partial differential equations, this mathematics is effectively reduced to consideration of ordinary differential equations alone.

Once the complete mathematical model has been obtained, the systems engineer proceeds to carry out his


COMPLETE MATHEMATICAL MODEL
(10) Dyna optimizations
TRANSFER FUNCTION MODEL
SECTIONALIZED MODEL
(5) Dyna optimizations
(9) Sta trients
(4) Non ear response relations
(8) Act equ rium relations
(14) Act equ rium relations
Nonlinear relationships
(3) Series of mixing stages plus time
(7) Ste ise lin fu ons
(13) Ste ise lin fu ons
(6) Metho small pertur tions
(2) Sing mixing stag lus dead me
(12) Metho f small pertur tions
(1) Series f first order ixing stages
(11) Sectio lizing of col n
Linear relationships

Building models of fractionators—Fig. 1

control study, with his immediate and main objective being that of obtaining a solution to the set of differential equations that comprise his model of the system. From this solution, the applicability of his proposed control scheme will be evident. As aids in carrying out this task, he has available the several theoretical analysis tools listed on p. 108, which are all methods of treating ordinary differential equations.

Page 108 also further expands the listing of specific methods of handling nonlinear systems.

Levels of Control System Capability

There are several degrees of required system capability or sophistication that may be used in specifying the control system to be applied to a particular process. Needless to say, the degree of mathematical complexity involved varies tremendously in going from the simpler controls to the more complex. The common classes or degrees of control that may be used include, in increasing complexity: environmental control; upset counteracting, or dynamic-response, control; steady-state optimization as basis of control adjustment; adaptive control; dynamic optimization.

Environmental control consists of controlling all process input streams so that upsets cannot reach the process. Thus, the required control system for the process itself can be quite simple. Such a scheme, quite often used in our industry, is impractical because of the large tankage required between units to ensure uniform stream flow and composition, and because ambient weather conditions—often of major importance to the process—cannot be controlled. To the control engineer, this means that a majority of the independent variables in environmental control are independently controlled; very few are subject to feedback from the process.

Dynamic response control, the most common method for all present-day control situations in which computing devices are not involved, builds the proper control action into the process with the addition of enough measuring and control instrumentation so that any normal upset reaching the process can be compensated for by its own action. The process will try to maintain itself at some preset operating level regardless of the conditions imposed by the independent process variables. In addition, only one set of adjustments of the controller operating modes will be used throughout the control period.

Steady-state optimization, the simplest and easiest to apply of the computer-control methods to be discussed here, allows the process to compute for itself a new best operating level if exterior conditions require such changes in order to maintain the process operation at some optimum, usually economic criteria.

Building models of reactors—Fig. 2 →

Such optimizations are computed under the assumption that the process is at steady state and can instantaneously be transferred from one steady-state level to another.

Adaptive control involves the addition of secondary control elements into the control system itself so that the operating modes of the primary control loops will always act to give the smoothest or fastest possible control. It thus operates to adjust the action of the dynamic-response control mentioned above.

Dynamic optimization control adds one more level of sophistication to that of steady-state optimization: the process is not only maintained at its optimum performance level while in the steady-state regime, but the change from one operating level to another is also made in such a way as to best satisfy the established control criteria, again usually economic. Such control is now only of academic interest because of the large computing capacity required to achieve it. Its practical attainment in the foreseeable future, however, is certainly highly possible.

The equations specifying the control components of the first two classes will almost always be linear in themselves. Thus, the systems of equations to be solved will only be nonlinear if the differential equations of the process itself are nonlinear. For the latter three types, on the other hand, the control equations are usually themselves nonlinear and necessitate the more complex computational methods regardless of the process complexity involved.

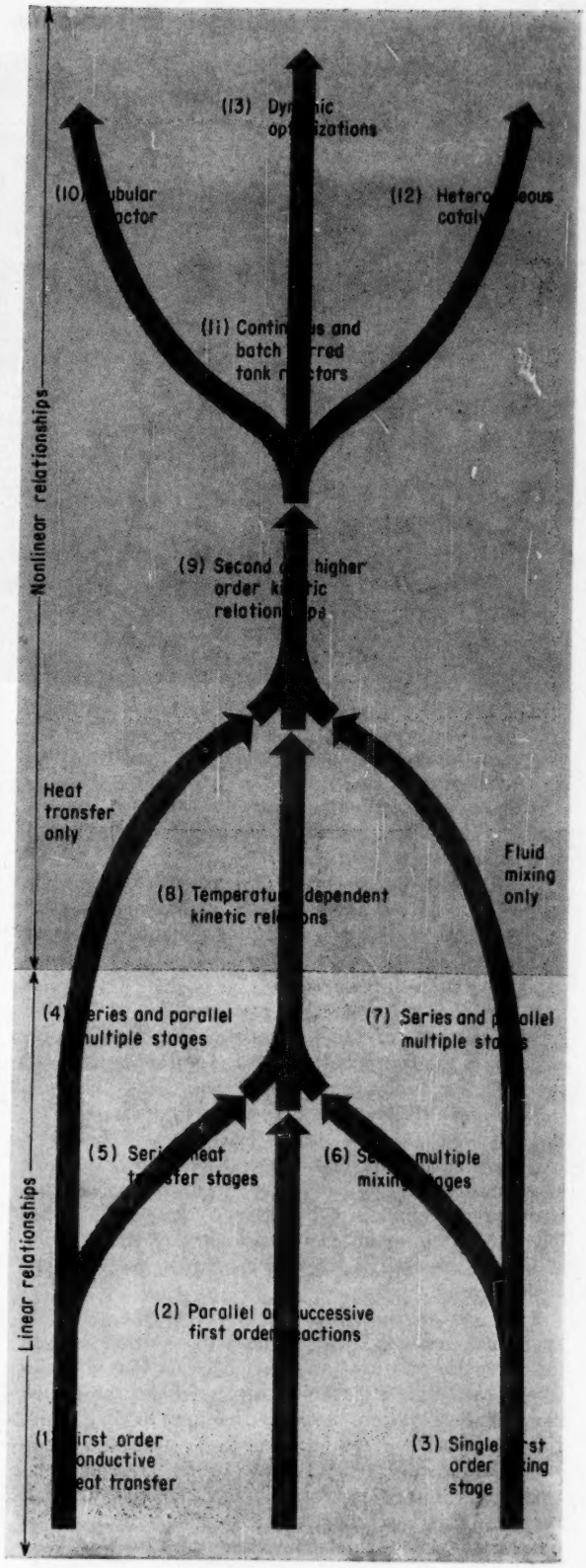
Characterization of Process Dynamics

Since the earlier parts[1] have given a description of several differential equation techniques, we'll discuss development of the mathematical models of chemical processes before discussing the two more complex types of control mentioned—adaptive and dynamic optimization.

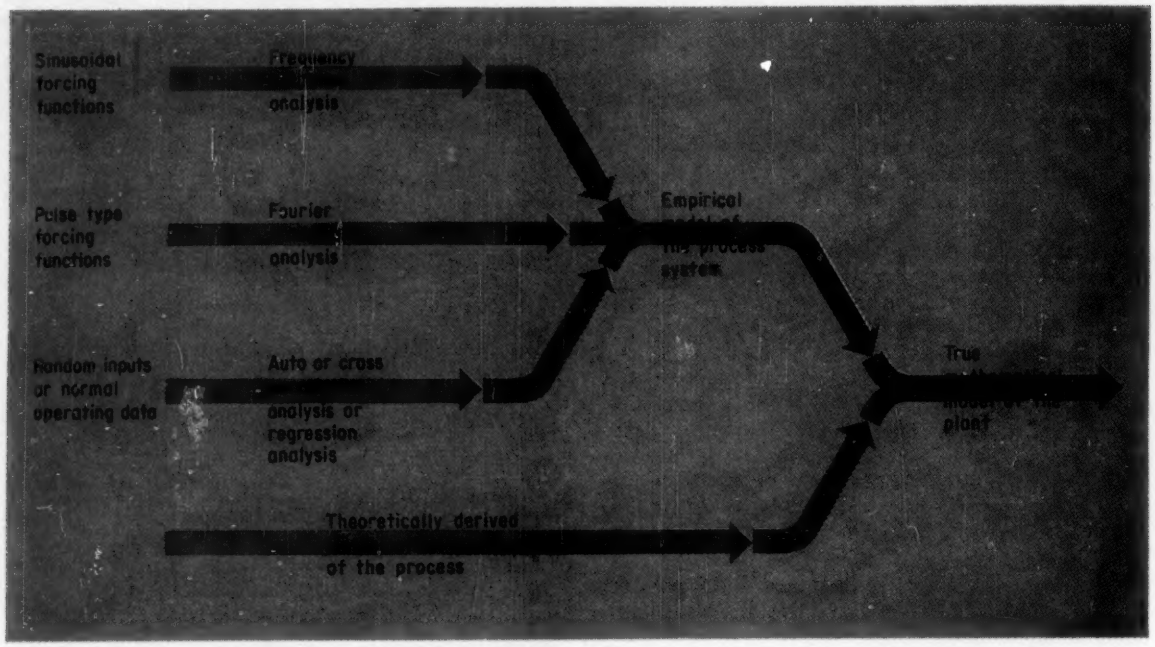
In Figs. 1 and 2, we have attempted to outline various common mathematical models that can be used to characterize the dynamic behavior of two chemical processes—fractionation columns (Fig. 1) and chemical reactors (Fig. 2). Chosen because they are probably the most common in our industry, between them they include practically all possible types of behaviors existing in chemical processing systems. The illustrations position the various possible methods in order of increasing exactness of representation unfortunately an order of increasing difficulty.

Representing Stagewise Separation

There are three possible methods of representing the dynamic responses, and hence the controllability,


(13) Dyn ic op zations
(10) ubular actor
(12) Hetera eous catal
(11) Contin s and batch rred tank r tors
Nonlinear relationships
(9) Second higher order ki ic relation pe
Heat transfer only
Fluid mixing only
(8) Temperatu dependent kinetic rel ons
(4) eries and parallel ultiple stages
(7) Series and p allel multiple sta s
(5) Seri eat sfer stages
(6) Se multiple mixi ages
Linear relationships
(2) Parallel o uccessive first order actions
(1) irst order onductive eat transfer
(3) Single st order ting stage

Relationship of plant testing, data reduction and theory to true plant model—Fig. 3



of stagewise separation processes by mathematical relationships. These are:

1. By over-all transfer functions relating the response of a chosen dependent variable to one or more independent variables.

2. By complete, theoretical mathematical models needed to satisfy a particular set of assumptions pertaining to the system as a family of ordinary or partial differential equations, including all pertinent dependent and independent variables.

3. By complete, theoretical mathematical models for specific sections of the column, whose action can be considered relatively independent of, or subsequent to, that of other sections of the column.

These are illustrated by the three branches of Fig. 1.

Within each class of mathematical model, there is an increasing complexity of representation possible as more exact, complete duplication of experimental behavior of apparatus becomes necessary, or the methods of available solutions, such as computer, become more sophisticated.

Since, as shown on p. 108, most of the available analytical and graphical methods of solution require linear representations and sets of equations of relatively low total order, these are listed on the lowest rung of the diagram. Actually, hand methods of solution are effectively restricted to those types of expressions listed as numbers (1) and (2), Fig. 1. Hand solutions are impractical for the more complex models because of the extremely large amounts of time required to accomplish them.

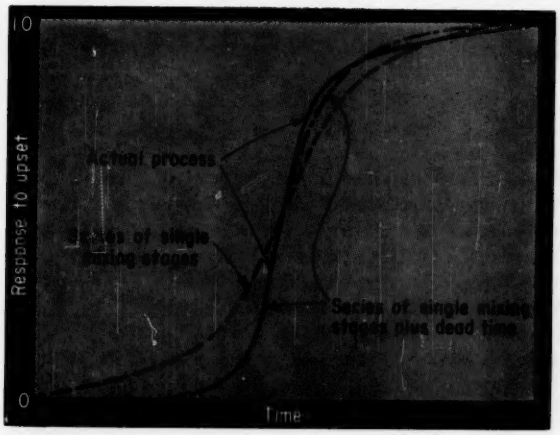
The over-all transfer-function model is the one that is most adaptable to the representation of experimental data. As outlined in Fig. 3, experimental response studies—whether carried out by frequency response methods,[11] pulse testing methods[12, 13] or as a result of statistical analysis of normal plant operating data,[14, 15] always result in an empirical mathematical model of the process because of the nearly hopeless possibility of having tested the complete response of the apparatus to all possible upsets.

In addition to the constraint of empiricism due to possible incompleteness of representation, the transfer function approach also suffers, since a different relationship must be written for each possible pair of independent and dependent variables. Too, such relationships are usually specific to particular apparatus under a certain set of operating conditions. Thus, they must be rederived for new conditions or a different column. As indicated in Fig. 3, however, such experimentally derived relationships are extremely valuable in guiding the development of the various theoretical models discussed later.

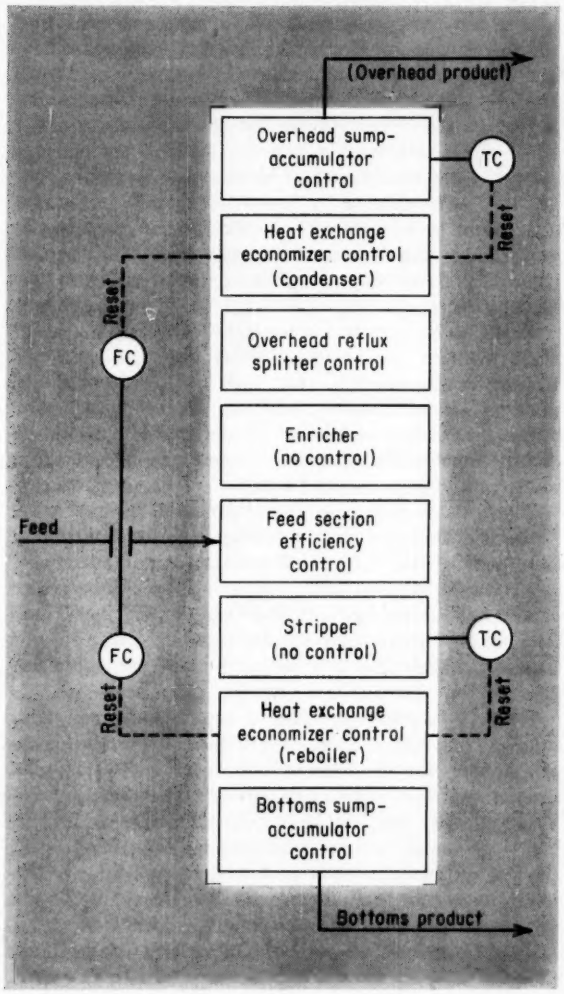
An example of the model, using a series of first-order mixing stages as representation of column performance (No. 1, Fig. 1) is given in Williams and Otto.[16] Excellent examples of the single mixing stages plus dead time (No. 2, 3) are given in the papers by Aikman[17] and by Hoyt and Stanton.[18] Examples of the two more complex representations are not yet in the literature to this author's knowledge.

It is possible to indicate the penalties involved in using the simpler relationships by considering Fig. 4,

Response of three column models—Fig. 4



Column control by sub units—Fig. 5



which shows types of response obtained from the various models compared to that of an actual column. Obviously the more complex the assumed transfer function, the closer the simulated response will match actual column response. The problem facing the control engineer is to decide between accuracy of representation and convenience of solution of the resulting equations.

To write a complete mathematical model of the distillation column or other separation device, involves writing the complete differential heat balance equations and complete differential material balances for all but one component for each stage or small group of stages in the process. Though such assumptions as adiabatic operation and equal molal overflow greatly simplify these relationships, the model for a column of any practical size is imposing.

The different levels of complexity of solution listed on the central arm of Fig. 1 refer mainly to the generality and, therefore, the difficulty of solution rather than to the size or complexity of the original mathematical model. The first listed methods solve nonlinear differential equations by imposing linearization techniques.

The method of small perturbations, as implied, makes the assumption that the process is displaced only slightly from its equilibrium values. Thus, all equilibrium relations, volatilities, temperatures, etc., can be considered constants. Over-all heat and material balance equations for the column are, as a result, linear and can be solved on an analog computer with a minimum of computing gear. The outstanding example of this approach is by Lamb and Pigford.[19]

The stepwise linear approach expands the applicability of the above method somewhat by allowing volatility relationships, etc., to be straight-line functions of temperature or concentration. Thus, the sets of equations are still linear, but considerably more computing equipment (about twice as much) is now needed. Pigford's work is again the source of the best examples of this technique.[20, 21]

Practically all actual equilibrium relations and relative volatility expressions are exponential or at least second-order expressions; they are decidedly nonlinear and drastically increase amount of equipment required to solve the mathematical model of the distillation column when range of variation of operating conditions demands their inclusion. This is particularly true when the transient response of the column during startup is considered. Published examples of such studies are best exemplified by the works of Rosenbrock[22] and of Williams and coworkers.[23]

Effect of these various methods of representation on analog computer equipment required for solution is that the method of small perturbations requires less than ten operation amplifiers for ten stages, for one-hundred stages, about 70. For same number of stages, nonlinear equilibrium relation and volatility expressions require 40 and nearly 400 amplifiers, respectively. But this isn't all. Nonlinear relationships also require considerable additional gear for multiplications, divi-

sion and function generation that wasn't necessary for the simpler expressions.

The extremely large amount of computational equipment necessary for representing the complete mathematical model for stagewise equipment has resulted in the concept of sectionalizing of such equipment as a compromise between the complete models and the overall transfer-function model. In this concept, the complete type of expression is written for all those stages utilized for a specific function in the column, such as the reboiler and associated hardware, the top section of column down to the overhead control sampling point, or the feed tray and immediately adjacent trays. Fig. 5 shows how a column may be sectionalized into sub units.

Just as was the case with the use of empirical expressions, the results of the above studies aren't directly extrapolatable to other pieces of equipment or other conditions. Entirely unsuitable for dynamic optimization, they would handle widely varying conditions such as startup only with extreme difficulty. They may be valuable, however, for control stabilization in very large columns where the complete model would be completely impractical because of its size.

Tools of the Control Engineer

For systems that can be considered linear:

Low to moderate complexity

- Analytical solutions of the differential equations of the system by (a) classical methods and (b) established short-cut methods such as the rules of Ziegler and Nichols.[2, 3]
- Graphical solutions by (a) frequency-response methods—Bode[3, 4, 5] and Nyquist[4, 5] and (b) transient-response methods—root-locus.[6]
- Analog computer simulation.

High complexity

- Only computer solution can give satisfactory answers for a reasonable expenditure of effort.

For systems treated as nonlinear:

Low complexity

- Analytical solutions.

Graphical solutions—phase plane analysis.[7, 8]

- Analog computer simulations.

Moderate to high complexity

- Only computer solution can give satisfactory answers for a reasonable expenditure of effort.

How to Solve Nonlinear Control Equations

- Direct analytic solutions—solution in closed form in terms of such known functions as elliptic and hyperelliptic. These apply to a relatively small special class of systems.
- Linearization of nonlinear terms in the equations. In the *method of small perturbations*, it's assumed that the deviation from steady state is small. Therefore, all nonlinear terms are treated as constants or considered to vary linearly with the independent variable. In *sectional linearizations* the range of variation is broken up into regions, and special linear forms of the nonlinear terms are written for each region that are considered to apply throughout that region. In *series linearizations*, the nonlinear terms are expanded in various series forms and the first terms used over the region of interest.
- Graphical procedures include construction of phase plane (two dimensional) and phase space (three dimensional) plots of nonlinear system response. Almost impossibly difficult for anything more complex than a third-order system, the procedures are the isocline method, Lienard's method and arc-segment methods.[8, 10]
- Analog computer solutions.
- Numerical methods of solution, particularly on digital computers.

Behavior of Chemical Reaction Systems

As is evident from Fig. 2, representation of the various levels of sophistication in mathematical model building for chemical reaction processes is not as straightforward as it is for the separation processes. The reactor really comprises three separate chemical engineering phenomena that occur simultaneously and with much more possibility of variable behavior than the previous case: chemical reaction; heat generation and transfer; and fluid dynamics, particularly mixing.

Since the simplest representations of chemical reactor behavior treat only one of these phenomena at a time, our chart must effectively have three starting points. Heat transfer may become quite complex and still be representable by linear differential equations, as long as the heat transfer coefficient and conductivity expressions can be considered constants or, at most, linear functions of one of the independent variables of the process.

Reaction processes, on the other hand, are restrictive if linear mathematics must apply. Thus, only first-order expressions that are not temperature-dependent are acceptable. Addition of second-order reactions or of temperature-dependent kinetic coefficients immediately causes nonlinearity in the equations and greatly increases difficulty of their solution.

Thus, all reaction systems of practical interest must be considered as being characterized by families of nonlinear differential equations and a computer considered as a necessity for such solutions. The work of Aris and Amundson,[24] of Beutler and Roberts,[25] and of Williams[26] gives complete descriptions of the specific types of models that are commonly used for representing reactor behavior.

For very complex systems, a separation of methods on Fig. 2 is again necessary. This is because the dynamic behavior of either tubular reactor systems or of reactors employing heterogeneous catalysis can be represented only by highly segmented finite difference relations using ordinary differential equations, or by partial differential equations. Their solutions as dynamic systems are extremely difficult, if not impossible, with present computing equipment. The homogeneous, stirred-tank reactor can be attacked by the methods of dynamic optimization for the simplest cases.

The usual treatment of a process control system does not take account of the fact that the optimum control settings of a nonlinear control loop can often change drastically over a wide range of operating variables. If control is adjusted for best performance near mid-range, it may be overdamped and sluggish at low operating levels and oscillatory at high levels.

To correct such behavior, the concept of adaptive control[27] has been formulated. As shown by Fig. 6, adaptive control is essentially a secondary control loop to vary settings of gains of the various operating modes of control instruments in the primary loop. The effect of such an addition upon the mathematics of the primary control system itself is to change a family of constant-coefficient ordinary differential equations to one of time-variable-coefficient ordinary differential equations. The mathematics of the secondary loop is a set of simultaneous algebraic or differential equations (one for each coefficient) that is solved along with the primary set.

Variation of control coefficients can be accomplished in several different ways, such as:

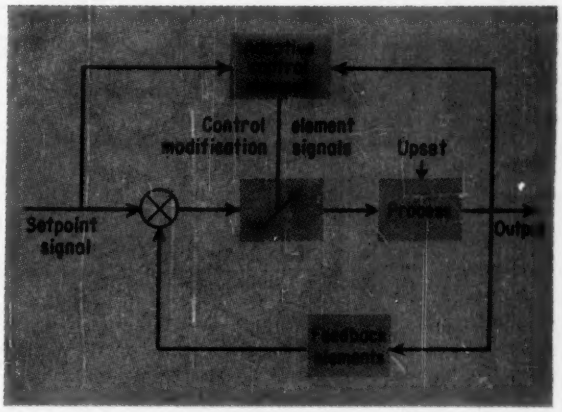
1. A preset algebraic function of the output-dependent variables may be used, if sufficient knowledge of system behavior is available.

2. A statistical test routine may be incorporated to alter the control routine, based on analysis of output data as they are obtained. This is important when insufficient knowledge of the process is available and is sometimes called a "learning" system.

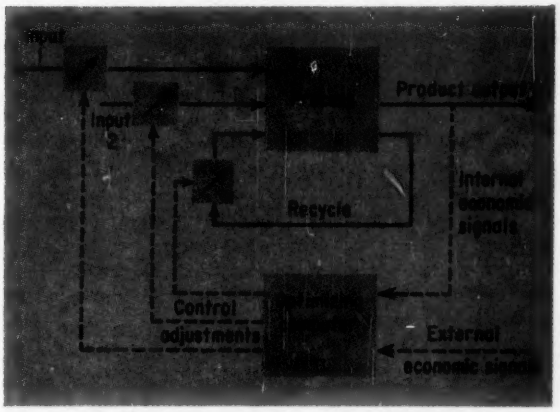
3. A system of differential equations may be used instead of the algebraic set where more exact control is required. Derivative and integral control changes can be made in the coefficients.

Examples of several adaptive control equations are given in the paper by Eisenhardt and Williams[28] on the computer control of an ammonia plant.

Add adaptive control to main loop—Fig. 6



Computer adds economics to control—Fig. 7



Optimalizing Control

Along with lack of consideration of changes in control response present in most standard control systems, is a lack of consideration of economic factors. Those more advanced control systems that account for economic factors by a secondary control loop are known as "optimalizing systems." Fig. 7 is an example.

If the optimizing loop is limited to algebraic relationships and steady-state process data, the control level is that of steady-state optimization as a basis for control adjustment. But the next obvious step is a combination of adaptive control and optimalizing control to give an economic optimizing system that can keep pace with dynamic behavior of the system. Such a method is known as "dynamic optimization." The mathematics of such a system usually involves the use of the calculus of variations to develop a set of Euler-Lagrange equations for each of the dependent variables of the process being controlled.

The problem by Williams and Otto[16] has provided an excellent media for tests of the applicability of dynamic optimization. Three papers[29-34] have appeared as answers to the problem. The work of the authors of these reports emphasizes the complexity of even the simplest chemical processing system when considered as an object for dynamic optimization and control.

Each of the authors confined his attention to the reactor portion of the model plant and in effect ignored the remainder of the plant. Such a selectivity in no way detracts from the importance and scholarship of their work; the reactor is by far the most important piece of equipment in the model process. Too, consideration of the complete process would probably have exceeded capacity of available computing equipment if the full model had been considered.

R. E. Boydston's paper[30] discussed the application of the dynamic control technique proposed by Kalman and associates[30, 31] to a linearized version of the generalized chemical processing model. His object was to use a digital computer as part of a plant control system to reduce to a minimum the amount of time the reactor is operating off the optimum point of operation after an upset in feed conditions occurs.

In his paper, Boydston derived the necessary mathe-

matical model to accomplish this and estimated that a machine of the capability of the Information Systems 609 would require about 1,000 words of memory and one thirtieth of available computing time to monitor and control the operation of a reactor such as described in the original model. Thus, a single computer could handle several reactors in parallel with a scheme such as proposed here.

The papers by Gould and associates tackled the problem of optimization of reactor control as a nonlinear system. The paper by Beecher and Gould[33] discussed possibilities of dynamic optimization by digital computer control. By means of the methods of variational calculus, they derived the set of Euler-Lagrange equations necessary to solve for the optimum correction path the reactor should follow after an upset.

Since the solution of these Euler-Lagrange equations is itself unstable, the set of equations must be continually resolved for existing reactor conditions and a new path calculated before the last has reached its point of divergence. Such a calculation, with the 14 equations necessary to specify the reactor and its control, is impossible with existing equipment in anything like real time. Therefore, Beecher showed the application of his method by a simpler example.

The paper by Kipiniak and Gould[34] proposed a solution to the difficulty encountered by Beecher by solving the 14 dynamic optimization equations off-line on available computers for a variety of initial conditions. From these solutions, a table of optimum controller actions to be taken for any possible reactor state away from the optimum is computed. By table lookup, a relatively simple control computer can then provide sophisticated dynamic optimized control of the reaction process.

Kipiniak and Gould also recomputed the optimum steady-state parameters of the process to a much more detailed degree than carried out by Williams and Otto in their original paper proposing the model. They obtained a different set of results, however, since a slightly different case was considered, i.e., the possibility of limited sale of product was not imposed and a somewhat different method of expressing the azeotrope in the distillation column was considered.

References

1. Williams, T. J., Systems Engineering, *Chem. Eng.*, Pt. 8, Aug. 22, '60, pp. 127-32; Pt. 9, Oct. 12, '60, pp. 181-6; Pt. 10, Nov. 14, '60, pp. 227-32; Pt. 11, Dec. 26, pp. 101-6.
2. Tucker, G. K., and Wills, D. M., "A Simplified Technique of Control System Engineering," Minneapolis-Honeywell Regulator Co., Philadelphia, 1958.
3. Holzbock, W. G., "Automatic Control, Principles and Practice," Reinhold, New York, 1958.
4. Ceaglske, N. H., "Automatic Process Control for Chemical Engineers," Wiley, New York, 1956.
5. Eckman, D. P., "Automatic Process Control," Wiley, New York, 1958.
6. Truxal, J. G., "Control Systems Synthesis," McGraw-Hill, New York, 1955.
7. Stout, T. M., *Trans. ASME*, **79**, 497 (1957).
8. Higgins, T. J., *Trans. ASME*, **79**, 445 (1957).
9. Paynter, H. M., and Takahashi, Y., *Trans. ASME*, **78**, 749 (1956).
10. Rausch, L. L., "Theory of Oscillations of Nonlinear Systems," U. of Mich., Ann Arbor, 1957.
11. Oldenburger, R. (ed.), "Frequency Response," Macmillan, New York, 1956.
12. Hougen, J. O., and Lees, S., *Ind. Eng. Chem.*, **48**, 1053 (1956).
13. Hougen, J. O., and Walsh, R. A., paper presented at 53rd annual meeting, AIChE, Washington, D. C., Dec. 1960.
14. Goodman, T. P., and Reswick, J. B., *Trans. ASME*, **78**, 259 (1956).
15. Reswick, J. B., *Control Eng.*, June 1955, pp. 50-7.
16. Williams, T. J., and Otto, R. E., paper CP 60-119, winter general meeting, AIEE, New York, Jan. 1960.
17. Aikman, A. R., *ISA Journal*, **3**, 412 (1956).
18. Hoyt, P. R., and Stanton, B. D., *Pet. Refiner*, Oct. 1953, pp. 115-9.
19. Lamb, D. E., and Pigford, R. L., paper presented at 52nd annual meeting, AIChE, San Francisco, Dec. 1959.
20. Pigford, R. L., Tepe, J. B., and Garrahan, C. J., *Ind. Eng. Chem.*, **43**, 2592 (1951).
21. Marshall, W. R., Jr., and Pigford, R. L., "The Application of Differential Equations to Chemical Engineering Problems," U. of Delaware, Newark, 1947, pp. 144-62.
22. Rosenbrock, H. H., *Brit. Chem. Eng.*, **3**, 364, 432, 491 (1958).
23. Williams, T. J., et al., *Ind. Eng. Chem.*, **47**, 2284 (1955); **48**, 1008 (1956); **50**, 1214 (1958; *Chem. Eng. Progr.*, **53**, 220 (1957).
24. Aris, R., and Amundson, N. R., *Chem. Eng. Sci.*, **7**, No. 3 121-55 (1958).
25. Beutler, J. A., and Roberts, J. B., *Chem. Eng. Progr.*, Feb. 1956, pp. 69F-74F.
26. Williams, T. J., *Control Eng.*, July 1958, pp. 100-8.
27. Eykhoff, P., *Trans. IRE, PGAC*, **AC-5**, No. 2, 148 (June 1960).
28. Eisenhardt, R. D., and Williams, T. J., *Control Eng.*, Nov. 1960, pp. 103-14.
29. Archer, D. H., *Brit. Chem. Eng.*, **5**, 88 (1960).
30. Kalman, R. E., Lapidus, L., and Shapiro, E., Report RC-76, IBM Research Laboratory, Yorktown Heights, N. Y.
31. Kalman, R. E., and Koepke, R. W., Report RC-77, IBM Research Laboratory, Yorktown Heights, N. Y.
32. Boydston, R. E., AIEE paper CP 60-979, Joint Automatic Control Conference, Cambridge, Mass., Sept. 1960.
33. Beecher, A. E., and Gould, L. A., AIEE paper CP 60-980, Joint Automatic Control Conference, Cambridge, Sept. 1960.
34. Kipiniak, W., and Gould, L. A., AIEE paper TP-60-982, Joint Automatic Control Conference, Cambridge, Sept. 1960.

Meet the Author

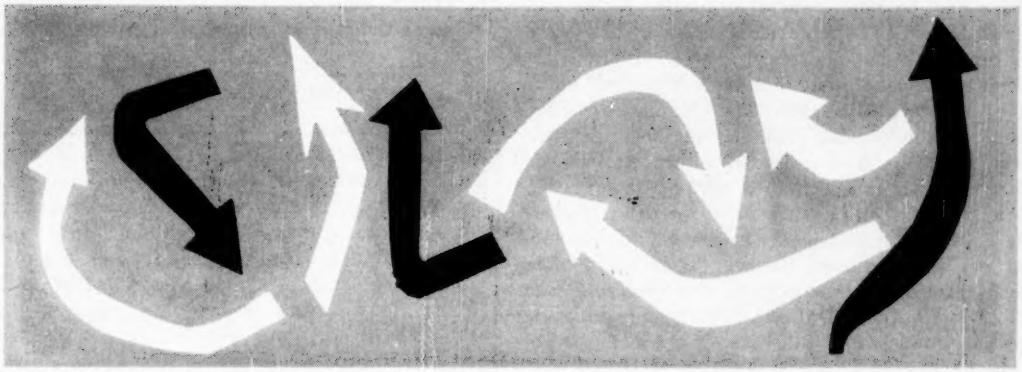
THEODORE J. WILLIAMS *is engineering supervisor, research and engineering division, Monsanto Chemical Co., in St. Louis, Mo. Long interested in the areas that are now being circumscribed by systems engineering, including chemical process control and analog computation, he is well-known for his efforts in combining them to attack chemical engineering problems.*

Williams received his B.S., M.S. and Ph.D. in chemical engineering at Penn State. Later he took an M.S. in electrical engineering at Ohio State. He taught at the Air Force Institute of Technology, where he became interested in analog computer possibilities. He joined Monsanto following this second tour of duty with the Air Force and organized the analog computer facility.

His prodigious output of papers (about 75) on many aspects of process control, dynamics and analog computation attest to the growth of his philosophy on CPI systems engineering. A registered professional engineer, he is a member of AIChE (and chairman of its process control comm.), ASEE, ACS and Tau Beta Pi.

He is well-known to Chemical Engineering readers through his series on systems engineering, currently appearing in the magazine, based on the 1959 Schoch Lecture at the University of Texas.

Conference on the New Chemical Engineering



Powerful Tool: Statistical Mechanics

How statistical theory of fluid transport phenomena can establish relationships between macroscopic properties of fluids and properties of molecules that make up the bulk sample.

JOHN S. DAHLER, *Dept. of Chemical Engineering, U. of Minnesota*

Chemical engineers are and will continue to be confronted by increasingly complex problems in research, development and production. To solve these problems, chemical engineers must, in many cases, augment time-tested methods of investigation with less-familiar techniques. These lesser known techniques are, however, not new. More nearly to the point, is that engineers and their research have recently reached a level of sophistication and competence such that they now expect to be, and indeed are, capable of applying a host of more powerful and general techniques to the solution of practical engineering problems. For example, it is only within the past few years that use of mathematical devices such as integral transforms and matrix calculus has become common in the field of chemical engineering. These same few years have witnessed a rapidly growing interest among engineers in the molecular interpretation of natural phenomena—an important new area.

Computing Machines Help

To a considerable extent, the practical utility of more sophisticated mathematical and physico-chemical tools can be associated with the advent of high-speed computing machines.

Thanks to the tremendous and ever-expanding capabilities of these devices, chemists, physicists and engineers of all breeds have in the years following World War II been able to tackle problems that were previously considered to be impossibly complex. Thus, chemists and physicists have been able to: critically evaluate theories of molecular and nuclear structure (with results not always to their liking); analyze in striking detail the results of X-ray and neutron-diffraction experiments; and perform the innumerable calculations necessary for the comparison of theoretical and experimental values of diffusion coefficients, thermal conductivity, viscosity, Joule-Thomson coefficients, dielectric properties, optical opacity, and all the other transfer and thermodynamical quantities so basic to engineering calculations.

Only a portion of this program could have been accomplished without the use of high-speed computing devices. Were it not for these machines, the chemical (and nuclear) reactor and process control calculations that are presently being conducted could never have taken place. And linear programming, that epitome of educated mountain climbing, probably never would have been developed.

Theory Behind Techniques

We will not attempt to adequately describe all the mathematical techniques that come to play in these calculations (including the simplex method of linear

programming, methods for solution of differential equations and boundary value problems, vector and tensor analysis). Instead, I should like to present a status report on the statistical theory of transport phenomena. Collected under this title, one finds many topics of theoretical, physical and chemical research that directly concern the chemical engineer, particularly the development of molecular interpretations for the bulk transport properties of matter.

To the chemist or physicist, the intrinsic interest of this endeavor is sufficient justification for its consideration. The engineer, however, demands a more practical incentive. Fortunately, the numerous and valuable contributions to the theory of rate processes, have so ably illustrated the sort of practical advantages to be gained from research in statistical mechanics.

Theories can, in general, be expected to accomplish at least four things: (1) explanation of existing experimental data; (2) correlation of these data in a fundamental rather than in an empirical fashion; (3) establishment of superior methods for extrapolation and interpolation; and (4) the suggestion of new experiments. In many cases, statistical mechanics has succeeded in meeting all or most of these requirements, while in others only partial success has been achieved so far.

Macro-Micro Relationships

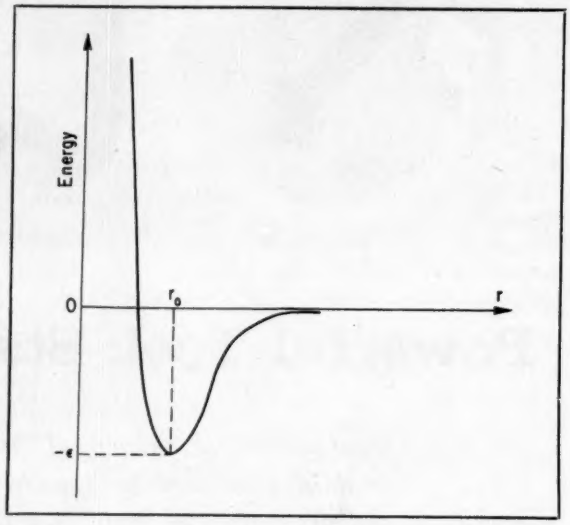
The goal of statistical theory is to establish the relationship between macroscopic properties of matter and properties of the molecules, atoms, and ions that constitute the bulk sample. These "molecular properties" include mass, dipole moments, polarizability, vibrational frequencies and strengths of chemical bonds, moments of inertia, and size. The "size" of a molecule really refers to the way in which it interacts with other molecules and/or with walls. Thus, if molecules were rigid bodies (for example, spheres or dumbbells) then their interactions would be solely repulsive, and operative only when their surfaces were in contact with one another. Under some circumstances, macroscopic properties are, indeed, so insensitive to the details of molecular interaction that the assumption of rigidity proves satisfactory. Often, however, more realistic representations for the interactions are required, where rigidity cannot be assumed.

At extremely small separations of less than one Angstrom unit (1 A = 10^{-8} cm.) the interaction force between two atoms is invariably large and of a repulsive nature. For slightly greater separations of from 1 to 2 A, interaction will be weakly attractive (or even repulsive) for atoms in chemically unreactive states, but very strongly attractive for chemically reactive species. As the separation is increased to 3 or 5 A and beyond, the forces rapidly diminish. These interactions are conveniently described in terms of the potential energy function $\phi(r)$ whose derivative, $F(r) = -d\,\phi(r)/dr$, is the magnitude of the force that the atoms exert upon one another when separated by a distance r.

A simple mathematical expression that reproduces the general characteristics of most atom-atom interactions is the Lennard-Jones 12-6 potential,

$$\phi(r) = \epsilon[(r_0/r)^{12} - 2(r_0/r)^6] \qquad (1)$$

The shape of this function is illustrated in Fig. 1,



where ϵ is the maximum attractive energy and r_0 the separation at which this maximum occurs.

For chemically unreactive species such as two rare gas atoms (or even polyatomic molecules such as CH_4, CO_2, or N_2) the energy parameter is on the order of a few hundred calories/mole. Weak interactions of this sort are frequently classified as van der Waals forces. They are responsible for the stability of condensed phases and other phenomena that we tend to characterize as physical rather than chemical. For chemically reactive states of free radicals such as an oxygen atom or (CH_3·) the energy parameter is essentially equal to the bond strength and so may be several hundred thousand calories/mole.

More Elaborate Functions

If instead of two atoms the species considered are more complicated in structure, it sometimes proves necessary to use more elaborate potential-energy functions. For spherically symmetrical small molecules, the Lennard-Jones function can often be used. But the interaction energy of two polar molecules will be more satisfactorily represented by:

$$\phi(r, \theta_1, \theta_2, \psi_2 - \psi_1) = \epsilon[(r_0/r)^{12} - 2(r_0/r)^6] \frac{-\mu_1\mu_2}{r^3}[2\cos\theta_1\cos\theta_2 - \sin\theta_1\sin\theta_2\cos(\psi_2 - \psi_1)] \qquad (2)$$

where μ_1 and μ_2 are the dipole moments and (θ_i, ψ_i) the polar spherical angles describing the orientation of the i-th dipole.

Although parameters such as ϵ and r_0 can in principle be determined from quantum mechanical calculations, this is in fact rarely possible to accomplish. Instead, values of the parameters are established by a

comparison of theory and experiment in a way that we shall presently explain.

Underpinnings of Theory

From these introductory remarks concerning intermolecular forces, let us now pass on to the statistical theory. Two approaches to this subject are possible. I could present a host of formulas chosen from the abundant literature on statistical mechanics. The alternate procedure, which shall be adopted here, is a consideration of the philosophical underpinnings of the theory, occasionally garnished with illustrative examples of its application.

To the engineer, this second approach will surely appear less practical than the first and, in the short run, this may very well be the case. However, as one becomes better acquainted with statistical mechanics, he discerns some subtle and often disturbing distinctions between his own intuitive definitions of probability and statistics and those that are employed by workers in the field of statistical mechanics. Once these connotative differences have been resolved, it is much easier for the occasional user of statistical mechanics to understand and to intelligently apply the products of research in this area. With these goals in mind, let us turn our attention to the language and methodology of statistical mechanics.

Consider a system composed of N identical and structureless molecules—atoms or molecules whose internal structures we choose to ignore. The total potential energy is taken to be the sum of pair energies in the manner:

$$\Phi = \phi(r_{12}) + \phi(r_{13}) + \ldots + \phi(r_{1N}) + \phi(r_{23}) + \ldots + \phi(r_{N-1N})$$
$$= \tfrac{1}{2} \sum_{i=1}^{N} \left[\sum_{j=1}^{N} \phi(r_{ij}) \right] \qquad (3)$$

Here, $r_{ij} = |r_j - r_i|$* is the separation between the i-th and j-th molecules. The total energy, equal to the sum of the potential and kinetic energies of all N molecules, is then:

$$E = \sum_{i=1}^{N} \frac{p_i^2}{2M} + \Phi = H(\mathrm{r}_1, \mathrm{r}_2, \ldots, \mathrm{p}_N) \qquad (4)$$

where $\mathrm{p}_i = mv_i$ is the linear momentum of i.

The dynamical behavior of the system is governed by the mechanical equations of motion,

$$\frac{d\mathrm{p}_i}{dt} = -\frac{\partial H}{\partial \mathrm{r}_i} = -\sum_{j \neq i}^{N} \frac{\mathrm{r}_i - \mathrm{r}_j}{r_{ij}} \frac{d\phi(r_{ij})}{dr_{ij}}; \quad i = 1, 2, \ldots, N \qquad (5)$$

which can, in principle, be integrated to provide a complete mathematical description of the system's development in time. To fully characterize the solutions of these equations, we must, however, specify initial values for the positions and momenta of all the molecules—that is, the solutions depend upon a total of $6N$ constants, where $N \sim 10^{23}$. There is no conceivable means by which we could experimentally determine the initial state of the system and so fix the values of these constants. Operationally, we are at best able to measure only a few properties of the system, such as its temperature, density, flow velocity. The thermodynamical and hydrodynamical behavior of the system, which is defined in terms of these macroscopic properties, must clearly be related to the properties of the individual molecules. However, the study of these relationships is by no means a matter of simply integrating the dynamical equations of motion, however impossible that might be to accomplish.

Rather, the problem may be described as one of inferring from the molecular nature of the system its thermodynamical and hydrodynamical properties. This leads us inevitably to statistical considerations, for our attention is now focused not upon the detailed dynamical evolution of the system but upon the most probable values for the various macroscopic observables.

Molecular Interpretations

For systems in thermodynamical equilibrium, the problem reduces to one of obtaining a molecular interpretation for the laws and functions of thermodynamics and of determining the relationship between temperature and other pertinent thermodynamical variables, such as the equation of state. More generally, investigations must include the irreversible response of a system to externally imposed stimuli and the dissipative processes involved in the approach to thermodynamical and mechanical equilibrium. Processes involved include rates of chemical reactions, fluid flow, relaxation phenomena, transfer of heat and matter. In general, a statistical theory of these phenomena should permit us to determine the limits of validity of the empirical laws for diffusion, viscous flow, etc., and to estimate solely from molecular information, values for coefficients associated with various irreversible processes.

The great obstacle to be surmounted in developing a theory for both equilibrium and non-equilibrium phenomena is that of constructing an adequate mathematical description for the system. Due to our lack of information concerning the velocities and positions of individual particles, this description cannot simply be that used in ordinary problems of mechanics. There will generally be an enormous variety of dynamical states consistent with a single thermo-hydrodynamical state of the system. With no operational means for determining which of these dynamical states may be associated with the system at hand, some sort of averaging procedure is clearly indicated—an average over the "hidden variables" not included within our limited set of observables. Thus, once given the thermo-hydrodynamical state, we require the probability for the system to be in each of the dynamically consistent states. However, before proceeding further in this direction, it is necessary to establish a more definite meaning for the term probability. It is this necessity

* Roman symbols refer to vectors. Thus, r_i is a shorthand notation for (x_i, y_i, z_i), the three Cartesian coordinates of the i-th molecule. Other symbols of which we shall make use are $d\mathrm{r}_i = dx_i\, dy_i\, dz_i$ and $d\mathrm{p}_i = dp_{xi}\, dp_{yi}\, dp_{zi}$.

that is physically (but not historically) responsible for the introduction of *ensembles.*

What Is an Ensemble?

An ensemble, representative of a particular state of a given thermo-hydrodynamical system, is defined as a collection of very many isolated systems, each dynamically identical with and in the same thermo-hydrodynamical state as the given system, but whose dynamical states may otherwise be unrestricted. Any one of the members of this ensemble could represent the thermo-hydrodynamical system.

Assuming that the number of molecules in the system is one of the thermo-hydrodynamical observables, the dynamical state of each member of the ensemble may be represented by a point in the $6N$ dimensional phase space of the variables $(\mathbf{r}^N, \mathbf{p}^N) = (\mathbf{r}_1, \mathbf{r}_2, \ldots, \mathbf{r}_N, \mathbf{p}_1, \ldots, \mathbf{p}_N)$. In the course of time, each of these points will trace out a trajectory in the phase space—a trajectory uniquely determined by the Hamiltonian function H and by the initial dynamical state of the ensemble member. Taken collectively, the motions of these phase points somewhat resemble the flow of a fluid whose density is associated with the number of representative points per unit extension in phase space. (In employing the concept of density, we assume the number of ensemble members is exceedingly great or even infinite.) The integral of this "density in phase" $(N\,D(\mathbf{r}^N, \mathbf{p}^N, t)$ over the entire space is just equal to the total number of ensemble members, N. Thus, $D(\mathbf{r}^N, \mathbf{p}^N, t)$ is the probability per unit extension in phase space and at the time t that a randomly chosen member of the ensemble will be in the dynamical state $(\mathbf{r}^N, \mathbf{p}^N)$.

Due to our definition, the initial distribution of system points—that described by $D(\mathbf{r}^N, \mathbf{p}^N, t)$—is representative of the prescribed thermo-hydrodynamical state of the system. Therefore, the phase-space trajectories subsequently traversed by the various ensemble members all represent paths along which the physical system under consideration actually might proceed. During the interval of time from t to $(t + \delta t)$ the number of representative points within a region V will change by an amount $N_v \int \partial D(\mathbf{r}^N, \mathbf{p}^N, t)/\partial t \, d\mathbf{r}^N \cdot d\mathbf{p}^N \, \delta t + 0(\delta t^2)$. Since the number of ensemble members remains constant, this change must be due solely to the passage of system points through the boundaries, S, of V. Since current density in phase space is $D\,\Sigma\,(\mathbf{p}'^{\dagger}_i + \mathbf{r}'^{\dagger}_i)$,

$$N \int_V \frac{\partial D}{\partial t}\, d\mathbf{r}^N d\mathbf{p}^N\, \delta t = -N \sum_{i=1}^{N} \int D[\mathbf{p}'_i + \mathbf{r}'_i] \cdot d\mathbf{S}\, \delta t + 0(\delta t^2) \quad (6)$$

where dS is the differential surface element. By performing an integration by parts (the divergence theorem) and making use of the equations of motion,

$$N \int_V \left[\frac{\partial D}{\partial t} + \sum_{i=1}^{N} (\mathbf{p}'_i \cdot \nabla \mathbf{p}_i + \mathbf{r}'_i \cdot \nabla \mathbf{r}_i) D\right] d\mathbf{r}^N d\mathbf{p}^N\, \delta t + 0(\delta t^2) = 0 \quad (7)$$

† First derivative with respect to time. †† Second derivative.

Since the choice of V is arbitrary

$$\frac{d}{dt} D(\mathbf{r}^N, \mathbf{p}_2^N, t) = \left[\frac{\partial}{\partial t} + \sum_{i=1}^{N} (\mathbf{p}'_i \cdot \nabla \mathbf{p}_i + \mathbf{r}'_i \cdot \nabla \mathbf{r}_i)\right] D(\mathbf{r}^N, \mathbf{p}^N, t) = 0 \quad (8)$$

which is a mathematical expression of Liouville's theorem. The flow of probability in phase space is therefore analogous to that of an incompressible fluid.*

Probability Functions

As we have just seen, $D(\mathbf{r}^N, \mathbf{p}^N, t)$ represents the probability that at time t a randomly chosen member of the ensemble will lie in the dynamical state $(\mathbf{r}^N, \mathbf{p}^N)$. Therefore, the probability of finding molecule 1 (there is a molecule 1 belonging to each member of the ensemble) in the state $(\mathbf{r}_1, \mathbf{p}_1)$, regardless of the states of the others, is equal to the fraction of ensemble members for which the coordinate and momentum of molecule 1 are $\mathbf{r}_1$ and $\mathbf{p}_1$, respectively, but for which the states of all other molecules are in no way restricted:

$$D^{(1)}(\mathbf{r}_1, \mathbf{p}_1, t) = \int \cdots \int D(\mathbf{r}^N, \mathbf{p}^N, t) d\mathbf{r}_2 d\mathbf{p}_2 \cdots d\mathbf{r}_N d\mathbf{p}_N \quad (9)$$

where $D^{(1)}$ is the specific μ-space distribution function. It is termed "specific" because it refers to a particular one of the N molecules, and "μ-space" because it refers to the point in the 6-dimensional phase space associated with dynamical motions of the individual molecules, i.e., "μ" for molecule. The space of system points, $(\mathbf{r}^N, \mathbf{p}^N)$, is called gas-space. From these definitions, we see that each point in the gas-space corresponds to a collection of N points $(\mathbf{r}_i, \mathbf{p}_i)$, $i = 1, 2, \ldots, N$, in μ-space.

If we now consider a *particular point* in μ-space, $(\mathbf{r}, \mathbf{p})$, then the probability that molecule 1 will lie there is given by $D^{(1)}(\mathbf{r}_1 = \mathbf{r}, \mathbf{p}_1 = \mathbf{p}, t) = D_1^{(1)}(\mathbf{r}, \mathbf{p}, t,$ In the same way, the specific distribution functions $D_i^{(1)}$, $i = 1, 2, \ldots, N$ for each of the remaining $N - 1$ molecules can be constructed.

For most purposes, we are interested not in the probability of finding a particular molecule at $(\mathbf{r}, \mathbf{p})$ but in the probability of finding any one molecule at this point. Because of this, it is convenient to introduce the generic μ-space or singlet distribution,

$$f^{(1)}(\mathbf{r}, \mathbf{p}, t) = \sum_{i=1}^{N} D_i^{(1)}(\mathbf{r}, \mathbf{p}, t) \quad (10)$$

Following the same line of reasoning outlined above:

$$n(\mathbf{r}, t) = \int f^{(1)}(\mathbf{r}, \mathbf{p}, t) d\mathbf{p} \quad (11)$$

gives the probability at time t of finding a molecule at the point r in physical space. Thus, $n(\mathbf{r}, t)$ is the statistical analogue of the number density, or the

* The equation of continuity for a fluid may be written as

$$\frac{d}{dt}\rho = \left(\frac{\partial}{\partial t} + \mathbf{u} \cdot \nabla_r\right)\rho = -\rho \nabla_r \cdot \mathbf{u}$$

where ρ is the density and $\mathbf{u}$, the hydrodynamical velocity. If the fluid is incompressible, $\nabla \cdot \mathbf{u} = 0$ and so $d\rho/dt = 0$ in analogy with Eq. (8).

number of molecules per unit volume. Mass density is related to n in the manner $\rho(\mathrm{r}, t) = m\, n\ (\mathrm{r}, t)$.

Similarly, the statistical counterpart to the hydrodynamical fluid velocity (at the point r and time t) is given by,

$$\mathrm{u}(\mathrm{r}, t) = \frac{1}{nm} \int f^{(1)}(\mathrm{r}, \mathrm{p}, t)\mathrm{p}\, d\mathrm{p} \tag{12}$$

These examples can be supplemented by others and a complete correlation between statistical and thermohydrodynamical quantities constructed.

Counterparts to Heat, Mass

The next step then is to establish what relationships exist among the quantities that are of physical importance. Thus, we must derive the statistical counterparts to the equations of heat, mass, and momentum transfer. The familiar equation of continuity is immediately obtained by integrating the Liouville equation over the momenta of all N molecules and over the positions of all but one. The equation of motion,

$$\frac{d\mathrm{u}}{dt} = \frac{1}{\rho} \nabla \cdot \tau + \mathrm{F} \tag{13}$$

is derived by multiplying the Liouville equation with p_1 and then performing the same integrations as before. F, the body force, is obtained by including in Φ the potential energy of the molecules due to any external force fields that may be present. The stress tensor appearing in Eq. (13) consists of two parts: τ_K with components of the form

$$\begin{aligned} \tau_{Kxx} &= -m \int f^{(1)}(\mathrm{p}/m - \mathrm{u})_x(\mathrm{p}/m - \mathrm{u})_x\, d\mathrm{p} \\ \tau_{Kxy} &= -m \int f^{(1)}(\mathrm{p}/m - \mathrm{u})_x(\mathrm{p}/m - \mathrm{u})_y\, d\mathrm{p} \end{aligned} \tag{14}$$

and τ_ϕ, a portion that depends explicitly upon the pair interactions of the molecules.

The first of these contributions describes the transfer of momentum that accompanies the chaotic thermal motions of individual molecules. This transfer mechanism, which is of prime importance at low fluid densities, is a familiar topic in the kinetic theory of gases. It is known that at equilibrium $f^{(1)}$ reduces to the Maxwell-Boltzmann function i.e., $f^{(1)} \propto \exp. - m/2kT\ (\mathrm{p}/m - \mathrm{u})^2$. Under these conditions, no viscous stresses exist and the only nonzero components of τ_K are $\tau_{Kxx} = \tau_{Kyy} = \tau_{Kzz} = -p_{id}$, where $p_{id} = nkT$ is the pressure of an ideal gas at the temperature T and number density n. Inhomogeneities in the flow field produce distortions of $f^{(1)}$ that when introduced into Eq. (14) give rise to stresses of the form,

$$\begin{aligned} \tau_{Kxx} &= -p_{id} + \eta_K \frac{2}{3}\left(2\frac{\partial u_x}{\partial x} - \frac{\partial u_y}{\partial y} - \frac{\partial u_z}{\partial z}\right) \\ \tau_{Kxy} &= \eta_K\left(\frac{\partial u_x}{\partial y} + \frac{\partial u_y}{\partial x}\right) \end{aligned} \tag{15}$$

Here, η_K is the "kinetic contribution" to the fluid viscosity.

The mechanism responsible for the stress τ_ϕ is somewhat less familiar to most. Because of the finite extent of intermolecular-force fields, molecules exert forces and hence transfer momentum to others in their vicinity. At equilibrium, these forces are in balance throughout the fluid and so contribute only to the static pressure. At low densities, the molecules are widely separate, on the average, from one another and so this contribution to the pressure is of minor importance. However, as the density is increased, molecular interactions at first give rise to incipient clustering and to observable gas imperfections and then finally to condensation. The properties of the condensate are almost entirely determined by these cohesive intermolecular forces.

Molecules and Viscosity

Intermolecular momentum transfers will, of course, also play a role in the viscous behavior of the fluid. However, because of the completely different mechanism involved, it is only natural to expect that the temperature dependence of η_ϕ, the viscosity coefficient associated with τ_ϕ, will differ greatly from that of η_K. In fact, both experiment and theory confirm that within certain limits $\eta_K \propto (T)^{\frac{1}{2}}$ and $\eta_\phi \propto \exp.\ (a/T)$. The first of these proportionalities can easily be derived from the crude free-path theory. The second has been qualitatively explained by Andrade in terms of the resistance to flow that is exerted upon a molecule by the force fields of its neighbors. Due to the confining influence of these neighbors, the molecule is severely restricted in its movements and so can only execute a type of vibrational motion. According to Andrade, it is at the turning points of these oscillations, when the molecule lies very near one of its neighbors, that the momentum transfer occurs.

Subsequent modifications and extensions of this theory have been suggested by Frenkle, Eyring and many others. At present, a concerted effort is being made to further develop the theory of viscosity in dense gases and liquids. The problems encountered in the study of dense fluids are among the most difficult with which the statistical mechanic has had to cope and so his success in this area has been less complete than in others. Several theories permit correct order-of-magnitude estimates of liquid viscosities but none so far has proved capable of quantitatively accounting for the details of temperature and pressure dependence, or of correlating viscosity with molecular structure. Until such a quantitative theory is developed, it will not be possible to predict with accuracy the viscosity of new or untested materials, or to extrapolate with authority into regions of pressure and temperature where no experimental data exist.

From a practical point of view, modern theories of liquid viscosity are no more reliable, and are considerably more difficult to apply, than the semiempirical formula of Andrade (or the Doolittle variant). However, current emphasis placed upon this subject indicates that the situation soon will improve.

Heat-Balance Equation

By performing a sequence of operations somewhat

more involved than that used in the derivation of Eq. (13), we obtain the heat-balance equation,

$$\frac{dh}{dt} - \frac{1}{\rho}\frac{dp}{dt} = \frac{1}{\rho}(\tau + Ip) : \nabla\mathbf{u} + \frac{1}{\rho}\nabla \cdot \mathbf{q} + \mathbf{F} \cdot \mathbf{u} \quad (16)$$

Here, h is the specific enthalpy and

$$\frac{1}{\rho}(\tau + Ip) : \nabla\mathbf{u} = \frac{1}{\rho}(\tau_{xx} + p)\frac{\partial u_x}{\partial x} + \frac{1}{\rho}(\tau_{xy})\left(\frac{\partial u_x}{\partial y} + \frac{\partial u_y}{\partial x}\right) + \ldots + \frac{1}{\rho}(\tau_{zz} + p)\frac{\partial u_z}{\partial z}$$

the rate of energy dissipation due to viscous losses and pV work. Here, q is the flux of sensible heat; i.e., $\int_V \nabla \cdot \mathbf{q}\, dV = \int_S \mathbf{q} \cdot \mathbf{n}\, dS$ equals the rate of heat flow from a region of volume V with a surface S to which the normal direction is n.

Just as in the case of τ, this heat flux is the sum of two parts,

$$\mathbf{q}_K = \int f^{(1)} \frac{m}{2}\left|\frac{\mathbf{p}}{m} - \mathbf{u}\right|^2 \left(\frac{\mathbf{p}}{m} - \mathbf{u}\right) d\mathbf{p} \quad (17)$$

the flux of kinetic energy that accompanies the random molecular motions, and q_ϕ, which represents the current of heat transferred from point to point in the fluid by virtue of intermolecular forces. At equilibrium, $\mathbf{q}_K = \mathbf{q}_\phi = 0$ but the presence of a temperature gradient distorts $f^{(1)}$ in such a way that,

$$\mathbf{q}_K = -\lambda_K \nabla T \quad (18)$$

where λ_K is the "kinetic contribution" to the thermal conductivity.

The first really serious attempt to calculate the intermolecular transfer portion of the thermal conductivity was probably made by Bridgman. Despite subsequent efforts by many investigators, existing theories of liquid thermal conductivities are no more satisfactory from a quantitative point of view than they are in the case of viscosity.

Shortcomings of Theory

In relating the shortcomings of the modern statistical theory of liquid transport phenomena, I have deliberately affected a rather derogatory manner. Also, as a first example of the theory's accomplishments, this is probably one of the least flattering that I could have chosen. There are several motives for this. First, it illustrates quite clearly, if perhaps somewhat too cursorily, a present limitation of the statistical theory. In this respect, it also serves to pinpoint one of the areas in which progress is most likely to occur in the near future.

Our present understanding of liquid-transport phenomena is characteristic of a stage through which most theories seem to pass—reasonably satisfactory empirical and semiempirical methods for estimating the transport coefficients are known and a variety of plausible mathematical theories have been developed. What we are lacking is a theory that is at once accurate, rigorous enough to allay suspicion, simple enough to permit practical calculations, and flexible enough to include within its range of validity a wide variety of physical conditions and molecular species.

Forty years ago, the kinetic theory of gases was in a similar stage of development. Today, it is a refined discipline that has repeatedly demonstrated its ability to explain, correlate, extrapolate and predict gas transport coefficients with a high degree of accuracy. Although it seems safe to assume that an equally satisfactory theory for liquids will not require so extended a period of gestation, unrealistic optimism may be somewhat out of place. The research of Kirkwood and his coworkers, of Born and Green, of Collins, Eisenshitz, and many others, has illustrated how sensitively calculations of transport coefficients depend upon the details of molecular arrangement in the liquid.

It is the collective and extremely complex nature of molecular motions in the liquid that renders any accurate mathematical description of them so very difficult.

Better on Gases

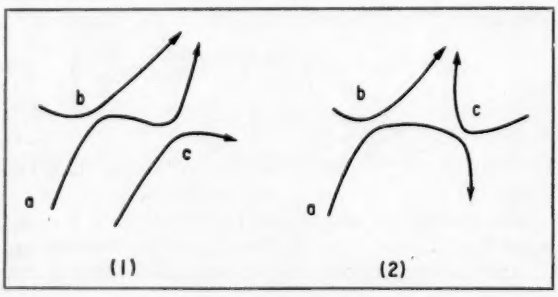
It is much easier to survey the successes of the transport theory for gases. Here, we have a mathematical theory that has survived repeated tests and innumerable modifications and generalizations.

From Eqs. (14) and (17), it follows that in a dilute gas the stress and heat flux are completely determined by the singlet distribution function $f^{(1)}$. In a multicomponent fluid containing several different molecular species rather than a separate singlet function, $f_\alpha^{(1)}$ would be required for each species α. The heat flux and stress tensor then become $\mathbf{q} = \Sigma_\alpha \mathbf{q}_\alpha$ and $\tau = \Sigma_\alpha \tau_\alpha$ where the separate terms in the series are precisely analogous to those given by Eqs. (14) and (17). Furthermore, the diffusion velocities of the various components may be written as,

$$\mathbf{V}_\alpha = n_\alpha^{-1} \int f_\alpha(\mathbf{p}_\alpha/m_\alpha - \mathbf{u})\, d\mathbf{p}_\alpha \quad (19)$$

The equation determining the function $f^{(1)}$ (in the multicomponent case, the $f_\alpha^{(1)}$'s) is obtained by integrating the Liouville equation over the momenta and coordinates of all but one molecule.

To simplify the resulting expressions, we assume "molecular chaos." According to this assumption, the momenta of two molecules that are about to collide with one another are completely uncorrelated. But this will certainly not be so if a small number of molecules suffer repeated collisions with one another. For then, each would retain an excellent memory of the recent dynamical histories of all the others with which it is colliding. The schematic collision diagrams shown in Fig. 2 give some indication of how this could come about.



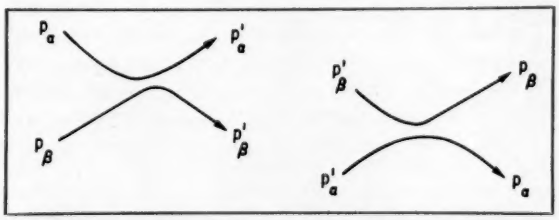
Fortunately, the occurrence of closed collisional cycles is very rare at gas densities and so a molecule can, indeed, be expected to forget enough of its dynamical history to assure the validity of the chaos assumption. (One of the difficulties of the liquid theory is the obvious inapplicability of this assumption.) Thus, the functions $f_\alpha^{(1)}$ may be characterized as solutions of the Boltzmann equations.

$$\left(\frac{\partial}{\partial t} + \frac{\mathbf{p}_\alpha}{m_\alpha} \cdot \nabla\right) f_\alpha^{(1)}(\mathbf{r}, \mathbf{p}_\alpha, t) = \frac{\partial_e f_\alpha^{(1)}}{\partial t} \qquad (20)$$

Here,

$$\frac{\partial_e f_\alpha^{(1)}}{\partial t} = 2\pi \sum_\beta \int\int [f_\alpha^{(1)}(\mathbf{r}, \mathbf{p}_\alpha', t) f_\beta^{(1)}(\mathbf{r}, \mathbf{p}_\beta', t) - f_\alpha^{(1)}(\mathbf{r}, \mathbf{p}_\alpha, t) f_\beta^{(1)}(\mathbf{r}, \mathbf{p}_\beta, t)]\, g\, b db\, d\mathbf{p}_\beta \qquad (21)$$

expresses the net rate at which collisions produce α-species molecules with momenta $\mathbf{p}_\alpha$. Diagrams illustrating collisions that produce $(\mathbf{p}_\alpha', \mathbf{p}_\beta') \rightarrow (\mathbf{p}_\alpha, \mathbf{p}_\beta)$ and destroy $(\mathbf{p}_\alpha, \mathbf{p}_\beta) \rightarrow (\mathbf{p}_\alpha', \mathbf{p}_\beta')$ molecules with the specified momentum are given in Fig. 3. The impact



parameter b is the distance by which two molecules would miss striking one another, were it not for the deflections of their trajectories caused by their mutual interactions. And $g = \left|\frac{\mathbf{p}_\beta}{m_\beta} - \frac{\mathbf{p}_\alpha}{m_\alpha}\right|$ is the relative speed of the two molecules prior to collision.

Results are Simple

To determine the primed variables $\mathbf{p}_\alpha'$ and $\mathbf{p}_\beta'$, it is first necessary to specify the pair potential ϕ. Once this has been done, it is then possible to calculate $\mathbf{p}_\alpha'$ and $\mathbf{p}_\beta'$ for each choice of b and g.

The set of coupled nonlinear integro-differential equations (20) represents a truly formidable mathematical problem. By modifying and extending the pioneering studies of Maxwell and Hilbert, Chapman and Enskog independently and almost simultaneously developed a practical iterative method of solution. The so-called "normal" solutions that they considered may be expressed in the forms,

$$f_\alpha^{(1)} = f_{\alpha 0}^{(1)} [1 - \mathbf{A}_\alpha \cdot \nabla \ln T - \mathbf{B}_\alpha : \nabla \mathbf{u} + n \sum_\beta C_\beta^\alpha \cdot \mathbf{d}_\beta] \qquad (22)$$

where

$$\mathbf{d}_\alpha = \nabla\left(\frac{n_\alpha}{n}\right) + \left(\frac{n_\alpha}{n} - \frac{n_\alpha m_\alpha}{p}\right) \nabla \ln p \qquad (23)$$

is a generalized diffusion force involving both concentration and pressure gradients. Here, $f_{\alpha 0}^{(1)}$ is the Maxwell-Boltzmann distribution characteristic of the equilibrium state and $\mathbf{A}_\alpha$, $\mathbf{B}_\alpha$ and C_β^α are functions of the molecular momentum $\mathbf{p}_\alpha$.

Although the mathematical theory underlying the Chapman-Enskog method for calculating these functions is extremely complicated, the final results are quite manageable. The theoretical estimates for q, τ, and V_α are obtained by substituting Eq. (22) into the appropriate definitions, e.g., Eqs. (14), (18) and (19), and then performing the integrations. As a result of this procedure, the coefficients of thermal conductivity, viscosity, diffusion and thermal diffusion can be expressed as a set of definite integrals. While these integrals do exhibit some dependence upon temperature, they are much more sensitively and significantly dependent upon the potential of intermolecular force.

How to Calculate Values

In practice, one calculates some transport coefficient, for example the viscosity, using a potential function such as that given by Eq. (1). The parameters r_0 and ϵ are then adjusted until agreement between theory and experiment is achieved. This procedure would be of rather limited value were it not for the fact that once potential parameters have been established on the basis of experimental viscosity data this same potential can be used to predict thermal conductivity and coefficients of ordinary and thermal diffusion. Reliability of these calculations will of course depend upon the degree to which the assumed potential function reproduces the actual intermolecular forces. In most cases, the Lennard-Jones 12-6 potential has proved admirably suited to this task. However, for helium and a few other molecular species, the somewhat more complicated Buckingham-exponential potential is more satisfactory. Extensive tables of the r_0 and ϵ parameters for the 12-6 potential (and also the parameters for various other potentials) have been prepared. From these tables, correlations with molecular structure are easily discernible and it is possible to make very educated guesses about the transport properties of gases for which no data exist.

Extrapolation of data from one temperature range to another is also easily accomplished. However, incautious use of temperature extrapolation can lead to sizable errors. The reason for this is that at a given temperature T_1 the average kinetic energy of a molecule lies very near to $3kT_1/2$. Therefore, most collisions that occur in the gas will involve energies of this same order. The molecular-scale information, transmitted in the form of measured transport coefficients, then reflects only that portion of the pair interaction potential for which $\phi \sim kT_1$. At a significantly higher temperature such as $10T_1$, a very different portion of the pair potential curve will be involved, and so estimates based upon the low temperature data may be unsuitable for accurate extrapolation. Fortunately, we can often obtain information about the pair potential from other sources such as spectroscopic and thermodynamic data, molecular-beam experiments and shock-tube measurements. Potentials obtained by these means have proved invaluable to the estimation of transport

coefficients at the high temperatures (15,000 °K.) involved in missile reentry problems. The development of this capacity should eventually prove very useful to the chemical engineer as he moves into the era of high-temperature chemistry.

Source of Error

Another source of error in extrapolations stems from the fact that interactions between oddly shaped or polar molecules really never can be represented by the 12-6 potential. The true interactions depend intimately upon their mutual orientation. Mathematical difficulties prevent us, however, from directly performing calculations of transport coefficients for most angle-dependent potentials.

At extremely high temperatures, the appearance of reactive molecular fragments and ions considerably complicates calculation of transport coefficients. Even at lower temperatures, the internal degrees of freedom possessed by polyatomic molecules call for corrections to the Chapman-Enskog theory. Thus, in addition to its kinetic energy, a polyatomic molecule bears a packet of vibrational and rotational energy as it races through the gas. The flux of heat transported is,

$$q_I = \Sigma_\alpha \Sigma_i E_{\alpha i} V_{\alpha i} n_{\alpha i} \qquad (24)$$

where $n_{\alpha i}$ denotes the number of α-specie molecules per unit volume with internal energy $E_{\alpha i}$. $V_{\alpha i}$ is the corresponding diffusion velocity.

If it is assumed that internal and translational energy come to equilibrium very rapidly, then the net effect of the internal degrees of freedom is to replace the thermal conductivity λ_K with $f\lambda_K$. The factor f is frequently called the Eucken correction. Our ability to accurately predict Eucken factors is still far from perfect—this is a problem to which considerable attention is currently being directed. Also, there are cases where the equilibration of internal and translational energy occurs so slowly that the concept of an Eucken correction is inappropriate. Except for these pathological situations, it seems reasonable to expect that Eucken corrections experimentally determined at lower temperatures can be used for high-temperature extrapolations.

Chemical Reactions Introduce Errors

Whether at high temperatures or low, the presence of chemically reactive species in the gas makes things difficult for the theoretician. However, Hirschfelder has illustrated that a considerable amount of progress can be made by extending the concept of Eucken corrections to situations of this sort. Thus, if the chemical composition rapidly adjusts to local conditions of temperature and pressure, the effect upon the thermal conductivity may be described by an Eucken factor that depends strongly upon the heat of reaction and equilibrium constants. The most interesting and potentially useful consequence of this is that the effective thermal conductivity of a reactive gas mixture can become many times greater than the conductivity of any of the single species involved. Applicability of this enhanced heat-transfer capacity to practical engineering situations is currently being studied.

When the assumption of quasi-equilibrium is inappropriate, we must go to a direct calculation of chemical reaction rates. Certainly, the most familiar and satisfactory theory presently available for this purpose is the transition state theory of Eyring.

This theory in one form or another has been applied to innumerable situations. When employed with sufficient finesse, its predictions are often surprisingly accurate. However, the present state of molecular quantum mechanics is not sufficiently advanced to allow for a complete mathematical characterization of the activated state.

Bibliography

1. Haar, ter D., "Elements of Statistical Mechanics," Rinehart, New York, 1958.
2. Landau, L. D., Lifshitz, E. M., "Statistical Physics," Addison-Wesley, Reading, Mass., 1958.
3. Hirschfelder, J. O., others, "Molecular Theory of Gases and Liquids," Wiley, New York, 1954.
4. Frenkel, J., "Kinetic Theory of Liquids," Dover, New York, 1955.
5. Jeans, J. H., "Dynamical Theory of Gases," Dover, New York, 1954.
6. Patterson, G. N., "Molecular Flow of Gases," Wiley, New York, 1956.
7. Bird, R. B., others, "Transport Phenomena," Wiley, New York, 1960.
8. Collins, F. C., Raffel, H., "Transport Process in Liquids," Vol. I, p. 135, Advances in Chemical Physics, Wiley, New York, 1958.
9. ASME symposium, "Thermodynamic and Transport Properties of Gases, Liquids and Solids," McGraw-Hill, New York.
10. Reid, R. C., Sherwood, T. K., "The Properties of Gases and Liquids," McGraw-Hill, New York, 1958.
11. "Handbuch der Physik, "Band XII, Springer-Verlag, Berlin, 1959. A series of papers on current status of statistical theory of gas transport properties.
12. Glasstone, S., Laidler, K. J., Eyring, H., "The Theory of Rate Processes," McGraw-Hill, New York, 1941.
13. Andrade, E. N. da C., *Phil. Mag.* **17**, 497, 698(1934); *Endeavour* **13**, 117(1954). On viscosity of liquids.
14. Bridgman, P. W., *Proc. Amer. Acad. Arts. Sci.*, **59**, 141 (1923). On thermal conductivity of liquids.

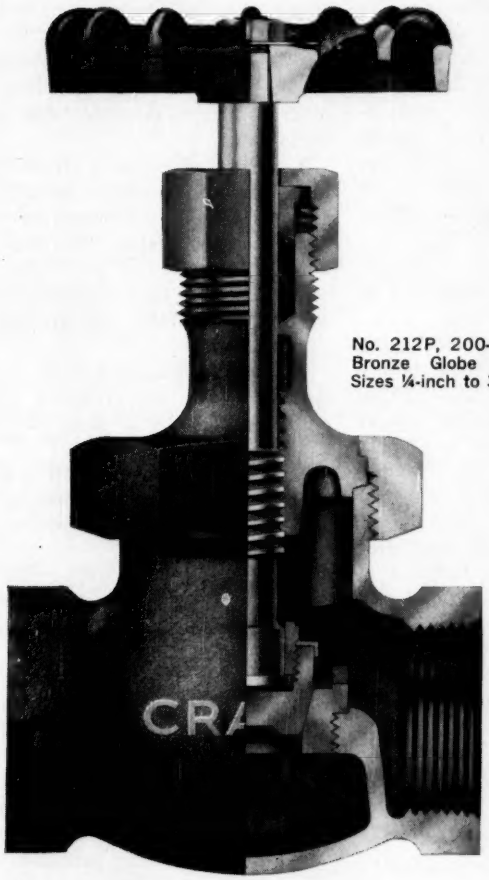
Meet the Author

JOHN S. DAHLER *is an assistant professor in the chemical engineering department, U. of Minnesota, Minneapolis, Minn. His primary research interests are the kinetic theory of gases and liquids, the theory of liquids and theory of intermolecular forces. He has published over 15 articles on these subjects in various journals.*

Professor Dahler received his undergraduate training in physical chemistry at the U. of Wichita and his Ph.D. in theoretical chemistry at the U. of Wisconsin (1955). After two years of military duty at Wright Air Development Center, Ohio, he joined the U. of Minnesota faculty.

Best choice for throttling service...

CRANE PLUG DISC BRONZE GLOBES



No. 212P, 200-Pound Bronze Globe Valve. Sizes ¼-inch to 3-inch.

These rugged valves are made for the toughest throttling jobs! Use them anywhere . . . on blow-off, boiler feed, soot blower, and drip and drain lines . . . then sit back and forget your maintenance worries.

Crane's "500 Brinell" stainless steel disc and seat give superior protection against corrosion and wear. The wide seating surface resists wiredrawing and damage from foreign matter. Deep stuffing box is filled with high grade packing.

Crane Plug Disc Bronze Globe Valves are made in 150-Pound, 200-Pound, and 300-Pound pressure classes, in a full range of sizes. Your Crane Distributor can ship your requirements from stock.

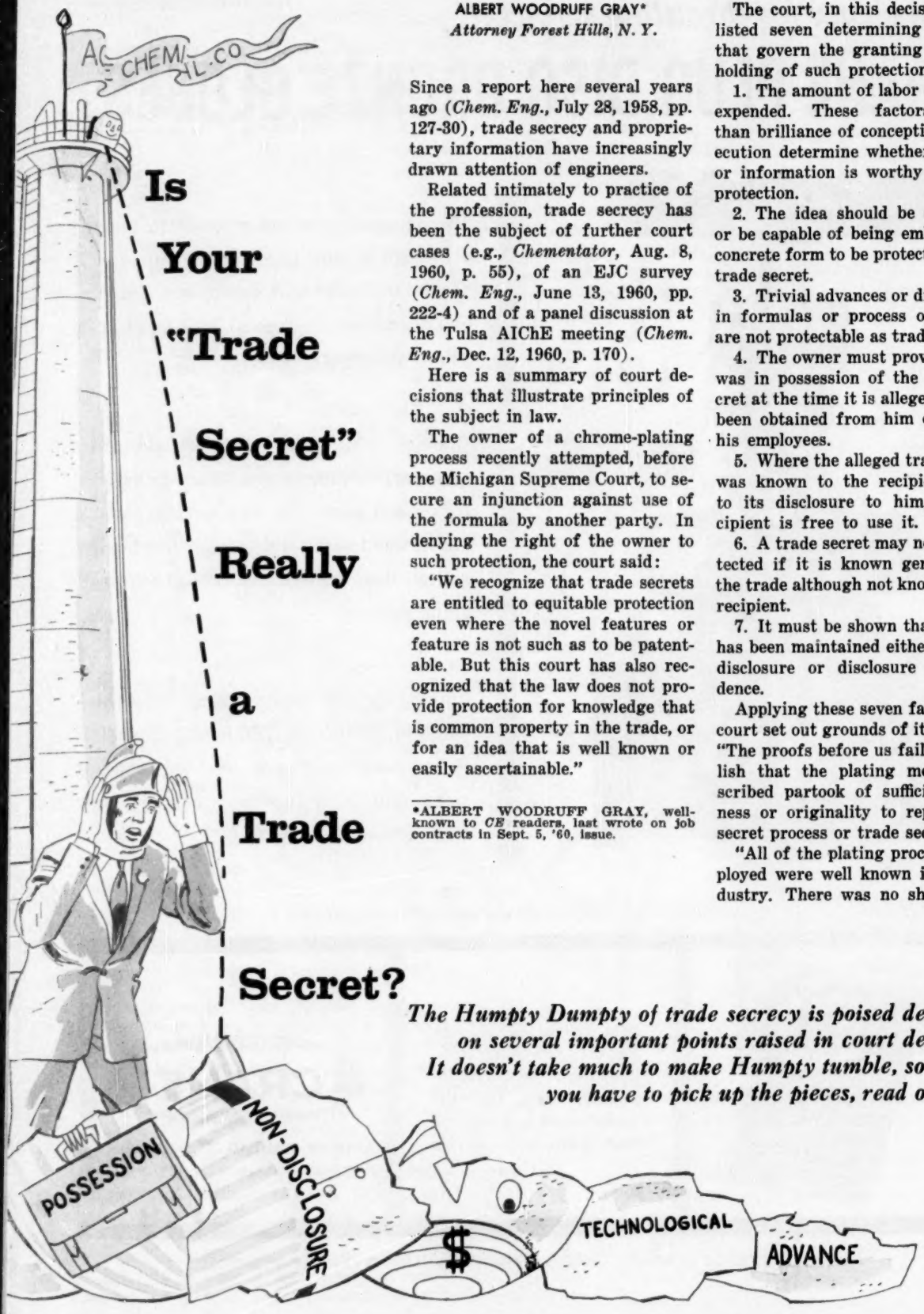
Crane Plug Disc Bronze Valves are also available in angle pattern

New! Write for your personal copy of Crane's Catalog 60. In it you'll find complete specifications on Crane's full line of bronze valves, and valves for every fluid handling service.

CRANE®

CRANE CO., INDUSTRIAL PRODUCTS GROUP
4100 South Kedzie Ave. • Chicago 32, Illinois

VALVES • ELECTRONIC CONTROLS • PIPING • PLUMBING • HEATING • AIR CONDITIONING



Is Your "Trade Secret" Really a Trade Secret?

ALBERT WOODRUFF GRAY*
Attorney Forest Hills, N. Y.

The Humpty Dumpty of trade secrecy is poised delicately on several important points raised in court decisions. It doesn't take much to make Humpty tumble, so before you have to pick up the pieces, read on here.

Since a report here several years ago (*Chem. Eng.*, July 28, 1958, pp. 127-30), trade secrecy and proprietary information have increasingly drawn attention of engineers.

Related intimately to practice of the profession, trade secrecy has been the subject of further court cases (e.g., *Chementator*, Aug. 8, 1960, p. 55), of an EJC survey (*Chem. Eng.*, June 13, 1960, pp. 222-4) and of a panel discussion at the Tulsa AIChE meeting (*Chem. Eng.*, Dec. 12, 1960, p. 170).

Here is a summary of court decisions that illustrate principles of the subject in law.

The owner of a chrome-plating process recently attempted, before the Michigan Supreme Court, to secure an injunction against use of the formula by another party. In denying the right of the owner to such protection, the court said:

"We recognize that trade secrets are entitled to equitable protection even where the novel features or feature is not such as to be patentable. But this court has also recognized that the law does not provide protection for knowledge that is common property in the trade, or for an idea that is well known or easily ascertainable."

The court, in this decision, then listed seven determining features that govern the granting or withholding of such protection:

1. The amount of labor or money expended. These factors rather than brilliance of conception or execution determine whether an idea or information is worthy of court protection.

2. The idea should be embodied or be capable of being embodied in concrete form to be protectable as a trade secret.

3. Trivial advances or differences in formulas or process operations are not protectable as trade secrets.

4. The owner must prove that he was in possession of the trade secret at the time it is alleged to have been obtained from him or one of his employees.

5. Where the alleged trade secret was known to the recipient prior to its disclosure to him, the recipient is free to use it.

6. A trade secret may not be protected if it is known generally to the trade although not known to the recipient.

7. It must be shown that secrecy has been maintained either by nondisclosure or disclosure in confidence.

Applying these seven factors, the court set out grounds of its refusal. "The proofs before us fail to establish that the plating method described partook of sufficient newness or originality to represent a secret process or trade secret.

"All of the plating processes employed were well known in the industry. There was no showing of

*ALBERT WOODRUFF GRAY, well-known to *CE* readers, last wrote on job contracts in Sept. 5, '60, issue.

lengthy or extensive research. The fortuitous combination did not achieve even a novel result. It achieved a desired result in a novel manner. Further, the process was disclosed to others in confidence."[1]

Difficult to Define?

Only a few months earlier, in a similar controversy before a Federal court in California, a manufacturer of silicon rectifiers claimed that a recording-tape manufacturer had acquired by conspiracy secret data, know-how and information in relation to a product.

Here again, information and processes involved were held not to be trade secrets, as outlined by the court, and hence were not to be made subject of an injunction for their protection.

"What is a trade secret is difficult to define. However, on the whole, it must consist of a particular form or construction or device, a formula, method or process that is of a character that does not occur to persons in the trade with knowledge of the state of the art, or which cannot be evolved by those skilled in the art from the theoretical description of the process or compilations or compendia of information or knowledge."

This was supplemented with the further characterization, "Trade secrets must be the particular secrets of the employer as distinguished from the general secrets of the trade in which he is engaged. For this reason, secrets acquired and developed as a result of long employment in the particular trade may be carried over and put to use by the new employer and for one's self.

"Trade practices, to come within the obligation of secrecy, must be secret. While they need not amount to invention, in the patent law sense, they must at least amount to discovery."[2]

Taking the Secret With You

A suit was brought by Monsanto Chemical Co. against a former employee in a Federal court in Utah. Involved was an ex-employee who had been with the company for 12 years, except for a period of military service. During his employment with Monsanto, he consulted in design and construction of an electric furnace for production of elemental phosphorus.

The engineer left the company and became a consultant in construction of a $14-million electrical furnace for phosphorus production by a Monsanto competitor. But in leaving Monsanto, he had taken over a hundred blueprints and drawings, in addition to know-how acquired there.

Asserting that the law doesn't permit one to whom such information had been trusted in confidence to enrich himself this way, the Federal court declared:

"One who discloses or uses another's trade secret without the privilege to do so is liable to the other if (a) he discovered the secret by improper means, or (b) his disclosures or use constituted a breach of confidence reposed in him by the other in disclosing the secret to him, or (c) he learned the secret from a third person with notice of the facts that it was a secret, and that the third person's disclosure of it was otherwise a breach of his duty to the other, or (d) he learned the secret with notice of the facts that it was a secret and that its disclosure was made to him by mistake."

After stating this general rule, the court continued, "That statement leaves unanswered the question of what comprises the type of trade secret referred to.

"The definition is included in the comment involving the idea that a trade secret may consist of any formula, pattern, device or compilation of information that is used in one's business and that gives him an opportunity to obtain an advantage over competitors who did not know or use it."[3]

The Captor and the Captured

Vital, too, to the protection of a trade secret is that the information or formula actually be secret.

Like the law relating to wild animals or birds in captivity, that of trade secrets says that, once in the public domain, they are no longer property but rather free for the use of all.

The right to exclusive use of the owner of a formula for production of iron pentacarbonyl was challenged in a Federal court by action against the proprietor. Of the process, claimed to be a trade secret by its proprietor, the court said, "Secrecy is the basis of this party's claim.

"Here, evidence tends to prove that many months and much labor were expended in developing a successful carbonyl process involving complicated mechanical and chemical problems.

"If all essential details have been disclosed, the process has become a part of the public domain and cannot be claimed as property. Although the inference from evidence that many major elements of the process are shown in prior art teachings is attainable, combination of these elements into a complicated production process amounted to a trade secret, if such combination represented a valuable contribution arising from its possessor's independent efforts."[4]

A Guidepost Decision

A Federal appellate court determined many years ago a controversy that has been cited often in later decisions. The reference is made as authority for the principle of law that recognizes information of trade-secret character as property subject to ownership and exclusive commercial enjoyment by its possessor.

Having left a laboratory-ware firm he had established, a skilled potter assigned to a competing firm a formula used in manufacture of the same product.

Suit to enjoin use of the formula was unsuccessful because it failed to show that disclosure involved a trade secret. In so deciding, however, the court laid down a definition of that term that has since been uniformly accepted by our courts.

"The rule is well settled that secret formulas and processes, such as are claimed to be involved here, are property rights that will be protected by injunction, not only as against those who attempt to disclose or use them in violation of confidential relations or contracts,

express or implied, but against those who are participating in such attempt with knowledge of such confidential relations or contract, though they might in time have reached the same result by their own independent experiments or efforts."[5]

An Exposition of Principle

Problems of trade secrecy are not as new as current interest in them might indicate. Over seventy years ago, litigation arose in New York State that led to an oft-repeated citation in later cases.

A pattern maker duplicated and appropriated to his own use the pattern of a rotary pump. Since the brass and iron used in manufacture of the pump expanded unequally in the finished machine, the necessary measurements and sizes weren't obtainable from it.

Said the court, in its decision, "The size of the patterns cannot be discovered by merely using the different sections of the pump, but various changes must be made and those changes can only be ascertained by a series of experiments involving the expenditure of both time and money.

"Are not the size and shape of the patterns, therefore, a secret that the owner has not published and in which he still has an exclusive property? Can it truthfully be said that this secret can be learned from the pump when experiments must be added to what can be learned from the pump before a pattern of the proper size can be made?

"As more could be learned by measuring the patterns than could be learned by measuring the component parts of the pump, was there not a secret that belonged to the discoverer until he abandoned it by publication or it was fairly discovered by another?

"If a valuable medicine, not protected by patent, is put upon the market, anyone may, if he can by chemical analysis and a series of experiments or by any other use of the medicine itself, aided by his own resources only, discover the ingredients and proportions.

"If he finds out the secret of the proportion, he may use it to any extent that he desires without danger of interference by the courts. But because this discovery may be possible by fair means, it would not justify a discovery by unfair means, such as the appropriation by a clerk who in the the course of his employment had aided in compounding the medicine and had thus become familiar with the formula.

"The fact that one secret can be discovered more easily than another does not affect the principle. Even a resort to the patterns of this inventor was more of a convenience than a necessity; still, if there was a secret, it belonged to him, and the pattern maker had no right to obtain it by unfair means or to use it after it was thus obtained."[6]

The principles of law enunciated in these six decisions seem clear and consistent. And the guidance they offer, in a period of renewed professional interest in trade secrets, may help employed engineers set their own standards of conduct.

References

1. Manos *v.* Melton, 100 N. W. 2d 235, Michigan, Jan. 4, 1960.
2. Sarkes Tarzian *v.* Audio Devices, 166 F. S. 250, California, Sept. 8, 1958.
3. Monsanto Chemical Co. *v.* Miller, 118 U. S. P. Q. 74, Utah, Apr. 22, 1958.
4. Ferroline Corp. *v.* General Aniline & Film Corp., 207 Fed. 2d 912, Illinois, Oct. 21, 1953.
5. Herold *v.* Herold China & Pottery Co., 257 Fed. 911, Feb. 7, 1919.
6. Taber *v.* Hoffman, 23 N. E. 12, New York, Dec. 10, 1889.

Walker Award to Northwestern Professor

At AIChE's Washington meeting last month, Professor Joe M. Smith, chairman of the chemical engineering department at Northwestern U., was named winner of the 1960 William H. Walker Award.

Granted annually for encouragement of excellence in contributions to the chemical engineering literature, the award was presented to Dr. Smith for, among other writings, his two McGraw-Hill books, "Introduction to Chemical Engineering Thermodynamics," and "Chemical Engineering Kinetics." He has also published nearly 60 articles on related topics.

What's the Trouble?

Despite new highs in starting salaries (a survey in the October issue of *Journal of College Placement* shows $525 for June 1960 chemical engineers), people entering the profession are fewer in number.

Office of Education, U. S. Dept. of Health, Education and Welfare, said a 2.5% decline in number of bachelor's degrees conferred in the 12 months ending June 30, 1960, resulted in 37,000-37,500 new engineers as compared with 38,134 in 1958-59. The drop had been predicted by dips in undergraduate engineering enrollment in the past several school years.

New Yardstick For Measuring Your Pay

U. S. Dept. of Labor's Bureau of Labor Statistics has just released its initial report on white-collar salary levels covering the winter of 1959-60 in industry. A preliminary look at the Bureau's aims for this national survey was given about a year ago (*Chem. Eng.*, Jan. 11, 1960, pp. 120-2).

Occupations covered were judged to be feasibly surveyed in industry and are numerically important groups in industry and Federal service.

What does it say about engineers? Six levels, starting with trainee-with-degree, defined the nearly 250,000 engineers within the scope of the study. Average annual salaries ranged from $6,371 for the lowest level to $14,193 for the highest.

In addition to details of salary ranges, the report ("National Survey of Professional, Administrative, Technical and Clerical Pay, Winter 1959-60") carries information on characteristics of the salary rate system applying to jobs studied, entrance rates for beginning engineers, chemists and mathematicians, pay distinctions among engineers based on field of specialization or function.

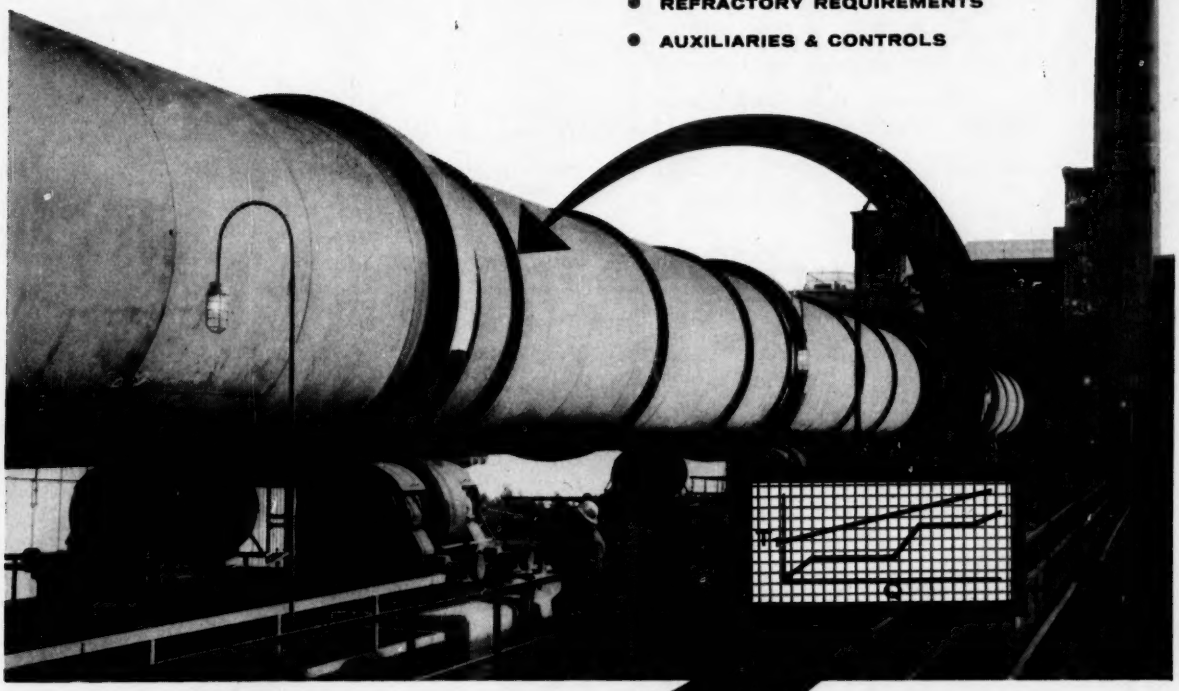
Look for more on this study in "You and Your Job" soon.

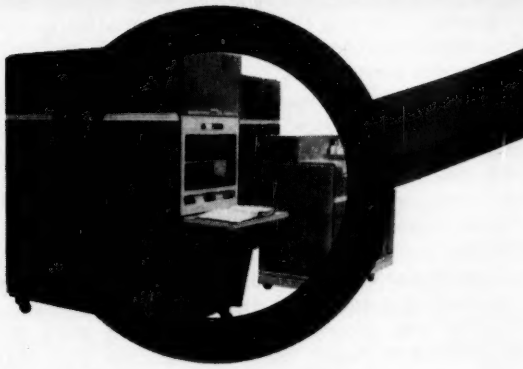
Another reason for the superiority of

KENNEDY ROTARY KILNS

KENNEDY has taken the *GUESSWORK* out of Rotary Kiln design by use of a modern digital computer to determine . . .

- HEAT TRANSFER
- FIRING EFFICIENCY
- OPTIMUM DIMENSIONS
- REFRACTORY REQUIREMENTS
- AUXILIARIES & CONTROLS





IBM 650 Data Processing System used by KENNEDY Engineers for Rotary Kiln Calculations.

For more information on Kennedy products, consult your Chemical Engineering Catalog

...kes the *more than 100 variables* in a kiln oper-...d in less than an hour solves the basic equations ...essary to determine optimum design.

KENNEDY's already established reputation in kilns for . . .

- Lime, dolomite & magnesite burning
- Cement, wet or dry process
- Ore nodulizing
- Coke calcining

. . . is further enhanced by this new, more scientific approach.

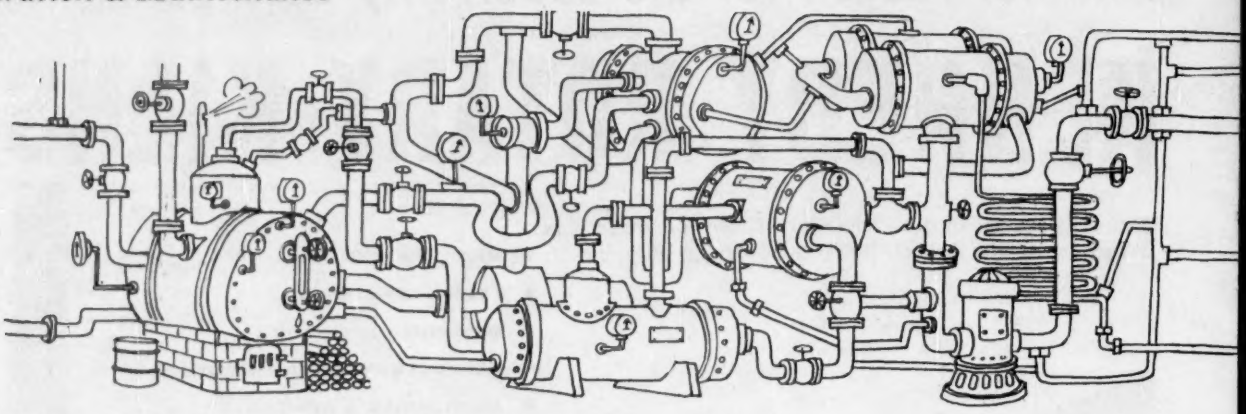
KVS

KENNEDY VAN SAUN

MANUFACTURING & ENGINEERING CORPORATION

405 PARK AVENUE, NEW YORK 22, N.Y. • FACTORY: DANVILLE, PA.

Primary & Secondary Gyratory Crushers • Jaw Crushers • Roll Crushers • Impact Breakers • Hammer Mills • Rod & Ball Mills • Kilns & Kilns Accessories • Dryers • Scrubbers • Screens • Pneumatic & Mechanical Conveyors • Complete Crushing, Lime, Cement & Carbon Paste Plants. Research & Testing Service.



"Know-how" is indispensable, but it isn't any good without "can-do," and "can-do" takes long practice to perfect. The designer of a plant can't necessarily run it.

Manufacturing: Is It Art or Science?

WINGATE H. RICHARDSON, *Consultant, N. Y.*

The other day, I met an old friend of mine who was employed by a firm that I had done some work for, a few years ago. After the usual, "How are you? What have you been doing?" and "How are things going?," I got around to asking about others in the organization with whom I had been acquainted. I was particularly interested in finding out what another friend, Charlie, was doing. Charlie was a production supervisor and a very good one.

Some months before, Charlie had called on me to ask if he could use my name as a reference in securing a new position. I told him that I would be glad to do this, but added:

"Don't you think you may be making a mistake by leaving your present company? You have been with it a long time and it's a good organization."

"If it's a mistake, I already made it. I quit last week."

"Why?"

"Well, our research department came up with a new product. It looked so good that the sales department sold $100,000 worth of the stuff on the basis of the research and development report. The company decided to turn the initial production over to the research department and we provided them with production facilities for this first order.

"But, after two months of effort, they hadn't been able to produce one pound of the material on a production basis. Things were getting a little hot, so they called me in and said they were turning the whole operation over to me. I was to stay with the job day and night until we got this order out.

"I refused. They wanted to know why and I wasn't hesitant in telling them: 'You pay your research men approximately twice what you pay your production men. Now, after listening to optimistic research reports for a number of months, you are in a real jam. If these men are as important to the company as their salary scale indicates, they should be able to solve this problem, for after all, it is their problem, and they know more about this material than anyone else. If, on the other hand, you are willing to admit that the skill of the production department is necessary to convert research into profits, then you should put the salaries in the production department on a comparable basis with the research department.'"

"Well, I'll admit I wasn't very tactful, but I had been coming to a slow boil about the company's attitude that production men are a dime a dozen while research men are minor gods. However, after some argument, I did take over the job and in three weeks we completed shipment. I stayed with the job practically day and night, too. So when everyone was happy again, I asked for a raise. I was turned down. So I quit."

Charlie said, after he quit, that he felt worn out. He and his wife hadn't had a real vacation for a long time, so they decided to go down and visit his folks for a month before he got down to the business of looking for another job.

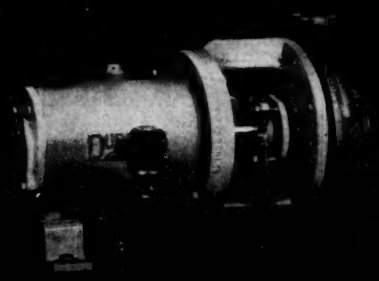
He sat down, did a little figuring, and came to the conclusion that he could live a more satisfying life in his home town and wind up the year with more money in the bank than he could by coming back here and living in our industrial smog. So he

HNO_3

H_3PO_4

HF

H_2SO_4



HCl

Specific design for pumping corrosives

Durcopumps have been specifically engineered for pumping process chemicals under highly corrosive conditions. For most concentrations and temperatures used industrially you can get a standard model Durcopump to meet your specific process and volume requirements.

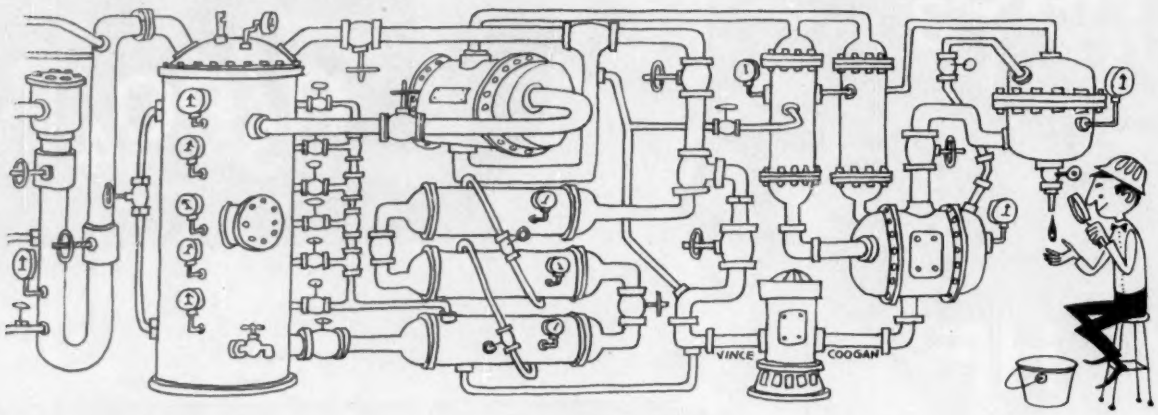
Pumps are available in fourteen alloys and special materials. Heads to 345 ft., capacities to 3500 gpm.

For advice on your specific application call your local Durco Engineer or write for Bulletin P-4-100.

DURCO

Serves the Process Industries

THE DURIRON COMPANY, INC., Dayton, Ohio / Pumps • Valves • Filters • Process Equipment



bought a gas-station there, then came back to get his furniture and say goodbye to his friends.

▶ **"Can Do," not "Know-How"**—I suppose that everyone has heard expressions of pride in the American "know-how." We frequently refer to an individual, or an organization, as one having "know-how." For some time, I have been thinking of the inherent weakness in that term.

The quality that makes an individual or an organization or a country stand out is the "can do." If you will stop and think about it a moment, I think that you will agree that the history of our country reflects our "can do" and not our "know-how."

Until recent years, much of our "know-how" was imported from abroad. Much still is. I don't wish to discredit the term "know-how" but let's face it—everyone "knows how" to swim for example, but not everyone "can do" it and if you find yourself in the water, hot or cold, which is more valuable to you, the "know-how" or the "can do"?

In the days when I was in school, much emphasis was given to the importance of the "practice of the art." Engineering was defined as the "art and science of utilizing the materials and forces of nature for the benefit of man." (Even today, our patent laws still require disclosure of the practice of the art and it is not necessary, in general, to give any explanation of the scientific principles involved.) The value of the skill of the individual in the practice of the art was universally recognized.

During one of the many inspection trips we took, we watched the "pan operator" make the "strike" in a sugar crystallization. As the crystallization progressed, he drew samples periodically, which he examined carefully on a flat wooden paddle. Towards the end of the operation, these samples were drawn faster and faster and finally, when the crystals "looked right," he gave the order to drop the batch to the centrifuge. Timing was important and our guide emphasized the importance of the skill of the pan operator in obtaining both a good quality product and a good yield.

▶ **The Feel of the Process**—It was some years later that I was in charge of operations involving a crystallization and I wanted my operators to develop the same type of skill.

"At regular and frequent intervals, I want you to climb up and look at the bed of crystals in the evaporator. The sight glasses are for that."

"I can't tell you exactly what you will see" I said, "or, for that matter, even what to look for. But I do know that if you will do this regularly, you will begin to see differences in the appearance of the magma from time to time, and these differences will come to have a meaning for you."

Some time later, one of our customers complained about the quality of our product—some of our crystals were sticky and were clogging his feeding mechanism. Our laboratory set up a simple procedure to test for stickiness. A 100-gm. sample was poured into a small kitchen-type funnel. Then the funnel was tapped until all of the crystals had gone through. The number of taps required was considered a measure of the stickiness. It was a simple, perhaps even crude, method of testing but effective.

Samples varied from 40 to 60 taps but with some lots the sample ran through freely without any tapping. All of these free-flowing samples were produced by operators under my supervision, and further investigation showed that none of the sticky material came from our operations.

I wouldn't want you to assume that all of this came from having a single operator watch the magma bed in the crystallizers, but it was certainly the result of encouraging the operators at every stage of the process to develop a personal skill and a "feel for the operations" they were running.

One extra dividend from this episode came from the intense pride my operators took in their work when they learned that they were producing the best product in the entire plant. I am afraid that they needled their friends in the other production units to the point where they made themselves obnoxious.

▶ **Leave Well-Enough Alone**—Well, of course, there was a sequel. "If one unit is producing a top-quality product, let's find out how they are doing it" said the engineers. So the "trouble shooters" from the engineering department descended upon us.

IF YOU WANT TO TAKE A CHANCE ON FALLING IN LOVE WITH A COMPUTER

When we designed Recomp we had just two people in mind: the man who would use it and the man who would approve the investment.

We told our design engineers we wanted Recomp to 1] have a large capacity, 2] be versatile, and 3] be easy to program. Then we urged our cost engineers to see to it that Recomp stayed in the lower price range.

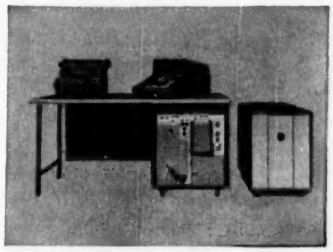
Quite honestly, this posed some problems. On occasion a designer would plead for his brainchild while the cost analyzers demurred.

No coins were tossed to settle such disagreements. If the designer could prove his idea made Recomp a better computer it was incorporated. That's how Recomp came to be the first solid-state digital computer on the market. And also why it was (and still is) the only compact computer with built-in floating-point arithmetic.

Fortunately when we were all through we found Recomp would sell at a sensible price. So, due to this strict attention to the computer's capability and cost, we're truly able to say **Recomp is the very best computer in the low-cost computer field.**

While they were at it, our engineers had some rather original ideas on how to present Recomp to you. "No gobbledygook," they said, "just give them the facts." So we painstakingly winnowed down a mass of superlatives to these plain facts:

1] Exclusive built-in floating point arithmetic.
2] Easy to program.
3] Efficient programming; 49 basic instructions expandable to 72.
4] Fast access time due to high-speed loops.
5] Magnetic disk memory with large capacity—up to 8192 instructions.
6] Large word length of 40 binary bits.
7] Each word contains two instructions.



8] Solid-state reliability.
9] Built-in square root command.
10] Large sub-routine and program library.
11] Active users group.
12] Built-in automatic conversion from decimal to binary.
13] Visual display of any word in memory.
14] Simple correction of errors.
15] Easily installed anywhere.
16] Can use conventional teletype equipment.
17] Low cost per computation.
18] High-speed input and output.
19] Programming training provided.
20] Large program exchange.
21] Coast-to-coast sales & service.

With all respect to our engineers, facts are fine but they can hardly do full justice to Recomp. For example, it's only fair to mention Recomp's appearance. Its soft color and modern shape bespeaks quiet efficiency; blends in the finest of surroundings. In this case you *can* tell the book by the cover. Recomp is truly a masterpiece of design (both in function and form). It's built to look as good as it is; a genuine pleasure to have around.

By the way, many of the points we listed above can be claimed by some other compact computers—but Recomp is the *only one* that can claim them *all*, and as standard equipment. You're never hemmed in on a problem by a lack of equipment.

True, you can get a computer that does more than Recomp, but this should only be if the size of the job justifies a much larger investment (and Recomp *does* have features you won't find in computers costing three times as much). Naturally, you can always find a computer that costs less.

But if you want a low-cost compact computer that performs favorably with the giants in size and cost, you should make a date to see Recomp. However, it's only fair to warn you, unless you want to take a chance on falling in love with a computer, don't write AUTONETICS INDUSTRIAL PRODUCTS, Dept. 016, 3400 East 70th Street, Long Beach, California. The **Autonetics Division of North American Aviation, Inc.**

"What are you doing that is different from the standard operating procedure used in the other units?" they asked.

"We are not doing anything different from that specified in the standard operating procedures" said I. "But I have taken the trouble to train my operators so that they are skilled in their work, and we simply do a better job. If you want to send some of the operators over from the other units for a while, *my* operators will be glad to train them."

This went over like the proverbial lead balloon.

"That's absurd" said the trouble shooters. "The operation is completely equipped with automatic controls. No skill is required for operation, and even if your operators did have superior skills, they could not use such skills in an automatically controlled process such as this. If you don't mind, we would like to make a study of your operations."

"That's O.K. with me" I said. "Just don't make any changes in our operating procedures without consulting me."

Then followed six weeks of intensive study of my operations. First, our dryer was running at a little different temperature than the other units. This was "corrected" long enough to get adequate samples, but the product was still free flowing. Then the centrifuge operation was changed.

One by one, the engineers went through every operation with the usual periods of elation when they had "found the answer," followed by the inevitable disappointment when the samples continued to show the desired free-flowing characteristics.

Finally, my visitors asked for a conference.

"We are under pressure from the front office to submit a report of our findings" they said. "We know that you know how to manufacture this material since every lot that you make is good. You never miss. We have talked this over among ourselves and have come to the conclusion that you have secret data on this process that you will not make available to us. This will be the substance of our report but we wanted you to know about it.

"We will include your explanation that the results you are getting are due to the training of, and skills acquired by, your operators. However, in an operation of this type, we simply cannot believe that the quality of the product produced is in any way related to the skills of your operators."

So we continued to make "no-tap crystals" and peace descended once again on our plant.

▶ **Any Jerk Can Operate**—Once upon a time, I was hired by a producing company engaged in the design of a new facility. Though I was employed for supervision of operations of the new facility, I spent the first several months in the engineering department assisting in the design of the plant. But this was more for the purpose of getting acquainted with the process than because of any contribution I might make to the design.

Finally, the day came when I was to leave for the site. Another production man and I were taking the night train and the project engineer drove us to the station. As we got out of the car, we received this parting instruction:

"Joe has been putting the heat on me to send Jack down to help with the startup," said the P.E. "When you get down there, tell him to lay off. I need Jack to get the design of this plant completed and the design of this plant is the most important part of the whole project. After all, any jerk can operate a plant."

With these final cheering words to two operating men, the project engineer drove off into the gloom of the early winter night. My friend and I looked at each other. It was quite a while before either of us felt like saying anything. Then, I said:

"Well, he's scheduled to operate the final unit. He'll learn."

By the time the final unit went on stream, the other units had been through their shakedown period. They were up to full production and, while there were still minor trouble spots, life was pretty comfortable. Our friend, the project engineer, became one of us—the jerks that operate the plant.

It was only a few days after he arrived that we began to get frantic telephone calls from him:

"My crystals look like snowballs. What do I do to get the size down?"

"My centrifuge has started dumping a mush into the crystal buggies. What do I do?"

"My towers are flooding. What do I do?"

"My crystals are black. What do I do?"

We had a stock answer.

"Don't worry about it. Probably some defect in the design of your unit. After all, any jerk can operate a well designed plant."

Well, of course, he finally got the point.

It has been said that every business man is looking for something that costs ten cents, sells for a dollar, and is habit forming. The "looking" is research. But once you have found your product and are actually in business, success depends upon your skill and ability in saving a profit out of the ninety cents differential between the cost of your raw materials and the price of your finished product.

To a large extent, your profit depends upon the efficiency of your production department. If your profit picture is poor, it might pay you to re-evaluate the real worth of your production operations with respect to the over-all picture. Dime-a-dozen operating engineers may be a luxury that you cannot afford.

This is the seventh in a series of articles on practical operations by an experienced operating man. Previous articles:

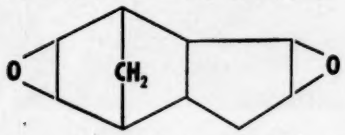
Temperature Control	**Sept. 21, 1959**
Inventory Cheating	**Nov. 30, 1959**
Specifications	**Feb. 8, 1960**
Salesmen	**May 2, 1960**
Safety	**July 11, 1960**
Stealing	**Oct. 17, 1960**

Progress Report...

New UNOX diepoxides for plastics

Many plastics producers are finding UNOX Epoxide 207 (dicyclopentadiene dioxide) an exciting new resin intermediate. With its compact molecular structure, UNOX 207 looks especially promising for high-temperature resins, glass fiber laminates, abrasive wheel and brake lining binders and adhesives, and encapsulating materials.

UNOX 207 is a white crystalline powder, and its structure looks like this . . .



The epoxy groups on UNOX Epoxide 207 are most reactive under acidic conditions. UNOX 207 cures rapidly with many common, low-cost hardeners to form plastics with high heat distortion temperatures. Illustrating this, test bars made with UNOX Epoxide 207, maleic anhydride, and trimethylol propane, retained a heat distortion temperature in the 300° C. range, even after aging for 400 hours at 260° C. Glass fiber laminates made from a system based on UNOX 207 were aged 192 hours at 500° F. and still had a flexural strength of 22,000 psi.

Diepoxide hardener systems have a long pot life at room temperature, but can be cured rapidly at higher temperatures. A good resin formulation for evaluation use is:

1.0 mole dicyclopentadiene dioxide
.8 mole maleic anhydride
.13 mole trimethylol propane

After being warmed slightly, then allowed to cool to 30° C., the resin has a viscosity of 100 cps. and a pot life of longer than a week. The mixture can be cured in a few minutes by raising its temperature to 130-140° C. For ultimate high heat distortion properties a high-temperature post-cure is recommended.

Stable "B" stage resins can be produced in solvent or as a dry powder. After six months on the shelf "B" stage UNOX 207 resins, prepared by prereacting 40 to 60 per cent of the available carboxyl groups, can be fused under mild pressures and temperatures of 160° C. They will also form up to 70 per cent solutions in acetone—toluene mixtures.

Fillers such as aluminum powder markedly improve impact strength and machineability. For two technical reports, "Resin-Forming Reactions of Epoxide 201" and "High-Temperature Epoxy Resins" or technical information sheets on UNOX Epoxides 206 and 207, please mail the coupon.

Water-resistant rubless floor polishes

When the kids play Lord Nelson in the family tub, and the rain outside has a way of tracking itself indoors—waxed floors become the target for spotting and marring.

The problem facing the floor polish formulator is to develop a polish that is resistant to water-spotting, and that can be removed easily when the floors are washed.

Morpholine answers these problems—

First, and most important, polishes prepared with morpholine are water-resistant in less than an hour—normally twenty minutes after application. This speed is equaled by no other material. Yet polishes based on morpholine can be removed easily by scrubbing with soap and water.

Secondly, with morpholine, wide variations in formulation can be tolerated with no serious change in the emulsion. In fact, an excess of morpholine even provides freeze-thaw stability.

Polishes based on morpholine form bright, even, wear-resistant films on linoleum, mastic, hardwood, and other floor surfaces.

To find out how you can take advantage of the properties of morpholine, check the coupon below for a copy of the paper "Performance of Morpholine in Floor Polish—Rate of Development of Water Resistance."

Tear out this coupon. Check the boxes on which you'd like more information, and mail to Dept. H, Union Carbide Chemicals Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y.

- ☐ Resin-Forming Reactions
- ☐ High-Temperature Epoxy Resins
- ☐ UNOX Epoxide 206 and 207 technical sheets
- ☐ Performance of Morpholine

Name_____

Position_____

Company_____

Street_____

City_____ Zone_____

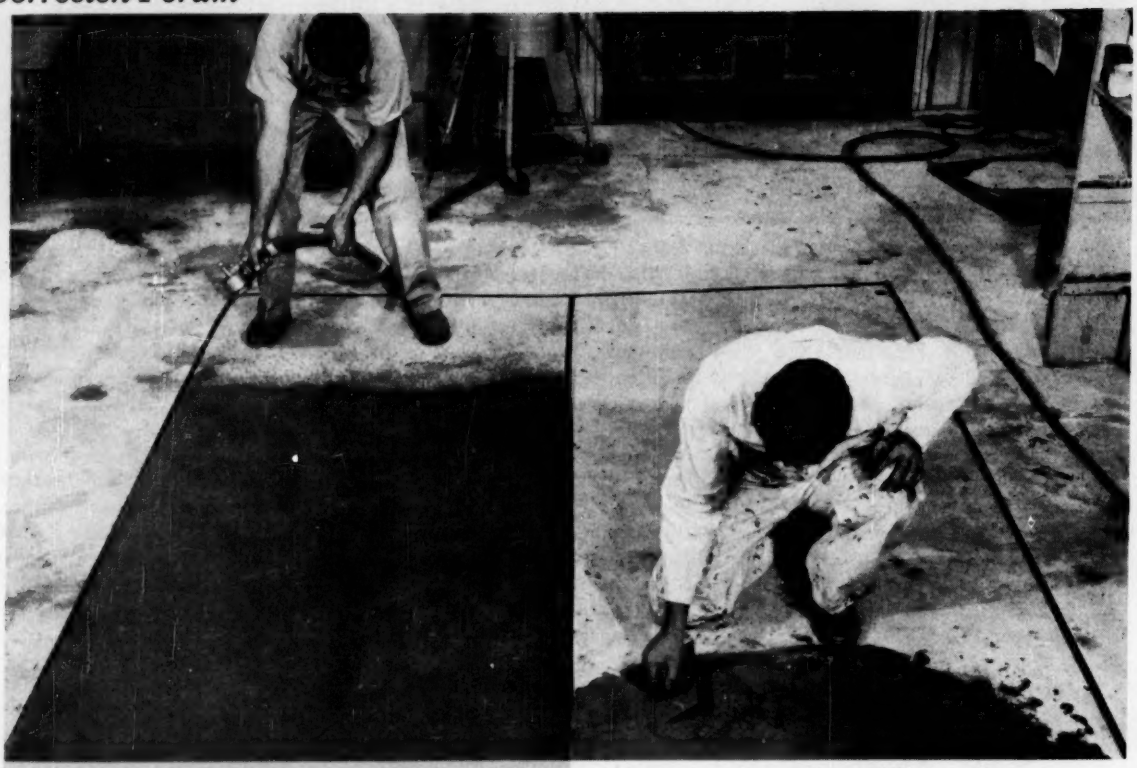
State_____

And remember, there is a CARBIDE sales office near you where you can obtain the services of a CARBIDE Technical Representative. His wide industry experience is backed by both extensive chemical training—and by Technical Specialists.

UNOX and UNION CARBIDE are registered trade marks.

UNION CARBIDE CHEMICALS COMPANY

UNION CARBIDE



Concrete protection costs come down as new spray technique eliminates troweling of "trowelable" coatings.

Spray "Trowelable" Coat on Concrete

At St. Louis, Mo., Carboline Co. is putting finishing touches on a spray gun that may have far-reaching effects in protecting chemical plants.

Spray-gun designs for coatings are dime-a-dozen. But Carboline engineers have come up with a unique gun in an area where sprays have been particularly unsuccessful —spraying of thick, "trowelable" protective coatings on concrete.

Compared with troweling, the new gun reduces application costs by 75%. And spraying is five times faster.

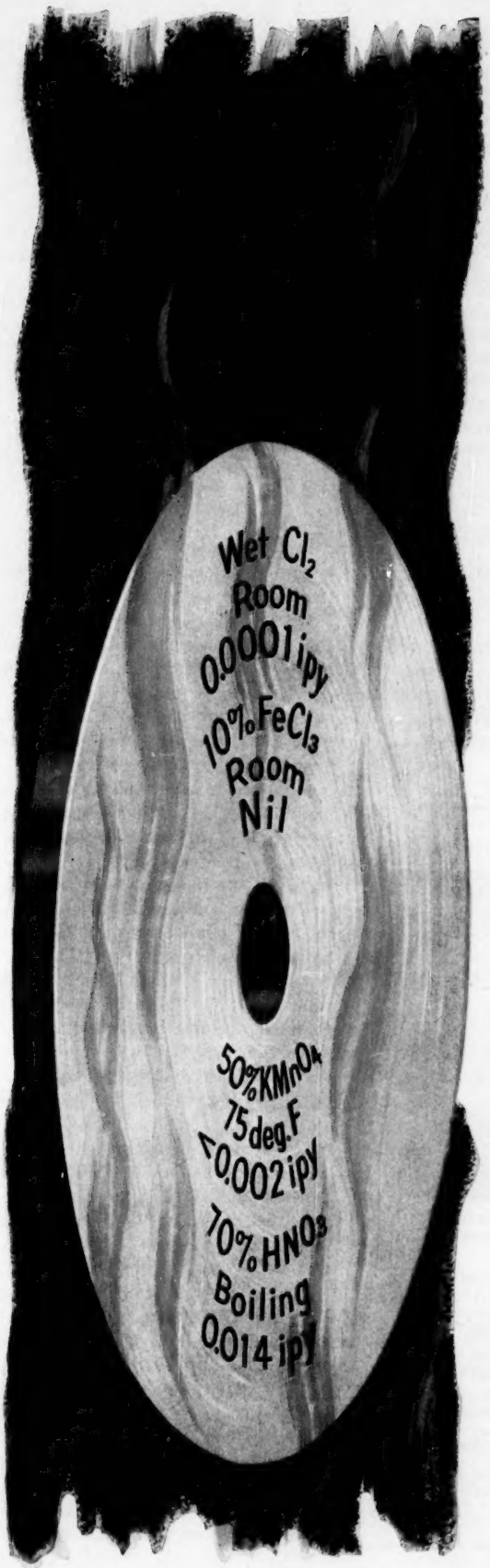
Actually, these thick coatings are a breed apart from thin paint, metallic or ceramic deposits used for corrosion protection. The coatings, which contain fillers, are at least $\frac{1}{16}$-in. thick, and usually have to be applied with a trowel.

Primary use has been to protect concrete floors and walls—no minor problem in process plants. The difficulty and expense of covering large concrete sections with a trowel-applied coating has forced many plant engineers to neglect or ignore concrete. Result: extensive deterioration of concrete from weather, corrosives (fumes, spillage) or abrasion.

▶**Large Unit** — Previous attempts at solving this problem centered around small-capacity spray units. But in the Carboline design, 10 gal. of catalyzed epoxy coating, containing silica or aluminum-oxide fillers, placed in a holding tank, covers 140-160 sq. ft., $\frac{1}{32}$-in. thick. The material, under air pressure, passes from the tank through a 2-in. flexible hose to the spray nozzle. Regulated air pressure then forces it into a conventional spray pattern.

Equipment is relatively lightweight, and a spray operator can move about as if he were handling an ordinary paint sprayer (*see photo*).

▶**Cost Advantages**—Stressing the cut in costs, Carboline engineers claim a crew of one trowel mason and a helper can cover 500 sq. ft. of concrete in an average day. Including overhead, this will amount to about $100/day for labor or about 20¢/sq. ft. However, a sprayer and helper can cover an average 2,500 sq. ft. daily. With overhead, this amounts to about $100/day for labor or about 4¢/sq. ft. Cost of the equipment will add 1¢/sq. ft. These figures do not include surface preparation or material costs, which will be the same for both methods. Therefore, percentage savings, on a total cost basis, will be somewhat lower than for labor costs. One disadvantage:



Corrosion from Oxidizing Chemicals?

...Test **HAYNES** Alloys

Even in such violently corrosive oxidizing agents as ferric chloride—at concentrations boosted to 40 per cent and temperatures as high as 140 deg. F.—HASTELLOY alloy C figuratively snaps its fingers. At room temperature, its reaction is nil!

Alloy C and other HAYNES alloys resist most of the common oxidizing chemicals. Alloy C also resists strongly oxidizing salts such as cupric chloride, ferric and cupric sulphate, and chromates and nitrates in sulphuric and hydrochloric acids.

Send for test samples

If oxidizing chemicals are causing excessive damage to equipment in your plant, you'll almost surely find the remedy among HAYNES alloys. We have been developing and producing corrosion-resistant alloys for thirty years.

Send us a letter outlining the corrosive conditions. This will help us select the proper HAYNES alloy samples to test for yourself. Be sure to ask for a booklet on HASTELLOY alloys. Address us at 270 Park Avenue, New York 17, N. Y.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY

Division of
Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

"Haynes," "Hastelloy," and "Union Carbide" are registered trade marks of Union Carbide Corporation.

Compare spray and trowel costs

	Spray Coat	Trowel Coat
Material	Heavy, catalyzed epoxy floor covering (mixed with silica, aluminum oxide or other fillers).	Heavy, catalyzed epoxy floor covering (mixed with fillers).
Total thickness	1/16 to 1/4-in.	1/8 to 1/4-in.
Description	Catalyzed coating in a 10-gal. tank passes, under air pressure, to a spray nozzle, then to surface.	Coating applied with hand trowel to floor or walls. Trowel must be dipped in solvent occasionally to provide clean surface.
Application costs*	One sprayer and one helper can cover about 2,500 sq. ft./day. Labor costs (Midwest), including overhead, will be 4¢/sq. ft. Cost of equipment adds 1¢/sq. ft.	One trowel mason and one helper will cover 500 sq. ft./day. Labor costs (Midwest), including overhead, will be 20¢/sq. ft.

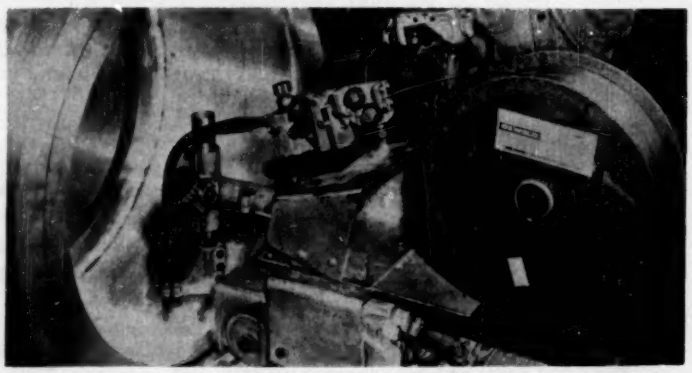
* Not including surface preparation or cost of material, which is the same for both methods.

spray cost advantages don't really show up below 800 sq. ft.

But costs are not the complete picture. Other advantages of spraying:

- Better control of thickness.
- Can use standard trowelable coatings.
- No trowel ridges.
- Easier to cover irregular surface such as pump bases, corners, wall joints.
- No buildup at drain slopes.
- Can be applied as thin as 1/16-in., up to any desired thickness on horizontal surfaces, with one coat.
- Can be sprayed up to 3/32-in. on vertical surfaces.

Square-butt welding: no bevels, backchipping



Heavy-wall aluminum cylinders can now be welded more economically, in fewer passes, with less total heat input and at increased speeds, thanks to a new technique called "square-butt" welding.

The Linde development eliminates vee-joint preparation, all preheating, backchipping and stringer-bead passes. Only the simplest joint preparation is required: a clean, square, end-to-end joint.

Known also as high-current welding, the new method uses shielded, inert-gas metal-arc equipment at about 600 amp. Prior to this, 400 amp. resulted in arc instability, severe oxidation and weld porosity. The solution to these problems: a combination of improved gas shielding and purity, wire quality and power-supply control. High current increases the heat input, keeps metal molten long enough to permit gases to bubble out, thus reduces porosity.

National Steel and Shipbuilding Co., San Diego, Calif., is using the method to construct 1¼-in.-thick aluminum cylinders for nuclear applications.

▶Tied to Epoxies—Carboline has tied the gun design to epoxy resins. For corrosive service, these coatings have excellent resistance to most organic and inorganic acids (except strong oxidizers), alkalis, salts, caustics and solvents, together with outstanding bond, tensile and compressive strengths.

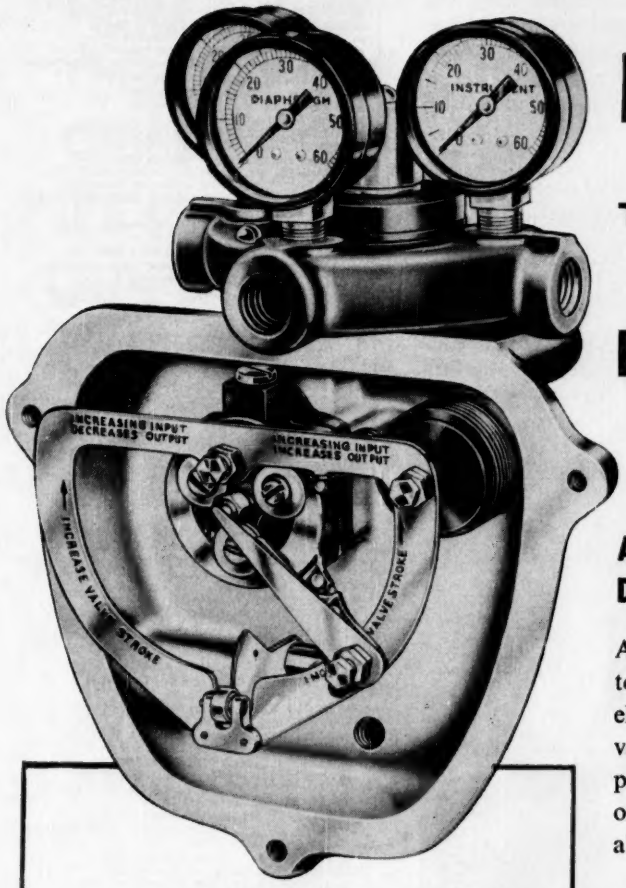
Other trowelable coatings, which can be handled at present in the new spray gun, include bituminous, latex, polyester protective coatings. Bituminous is an asphalt, bitumen or coal tar product. It has moderate chemical resistance. Latexes usually contain vinyl, acrylic or butadiene-styrene, water and cement. They have fairly good chemical and wear resistance. Polyester coatings usually consist of a resin, catalyst and diluent, together with an inert filler. Chemical resistance is good against oxidizers.

▶Surface Preparation—Since the best coating available naturally will fail if applied to improperly prepared areas, the spray coating must be put down only over clean, strong, dry surfaces.

New concrete will usually call for a detergent cleaning. And old concrete, badly deteriorated, should be resurfaced. If still in good condition, old concrete should be cleaned chemically or by sand blasting.

Aside from protecting concrete, sprayable, thick epoxy coatings should find applications in the lining of vessels, tanks, stacks. Other possibilities: on pipe, repairs.

A new concept in design makes possible the...



FISHER

TYPE 3560 VALVE POSITIONER

V/P

Assured product performance through DYNAMIC ANALYSIS engineering

Application of mathematical techniques of design to pressure control systems has enabled Fisher to eliminate the conventional approach in the development of the new V/P valve positioner. It has provided the V/P with the following combination of characteristics and performance . . . unobtainable in any other type of valve positioner.

SMALL AND COMPACT . . . only 6⅝" wide and 8¾" high (with gauges).

CONVENIENT ADJUSTMENT . . . valve stroke and zero adjustment readily accessible and easy to make.

SPLIT RANGE . . . no parts change whatsoever is required for split range operation.

EASILY REVERSIBLE . . . reversed by simply moving flapper arm from one beam quadrant to the opposite quadrant.

CHARACTERIZED CAMS . . . offer wide flexibility in valve characteristics.

PERFORMANCE DATA

Hysteresis, (Average)	0.0012"
Linearity	as required. Change cams to obtain desired characteristics
Sensitivity	0.14 psi
Resolution Sensitivity	0.002 psi
Repeatability	±0.0003"
Stroking Speed	0.37 in/sec.
Air Consumption	10 scfh
Break Frequency (5% of instrument pressure range)	3.9 cps
Break Frequency (3% of instrument pressure range)	4.6 cps

The above performance data was taken from laboratory tests on a Type 657 diaphragm actuator, Size 40, with 1½" travel. Instrument range 3 to 15 psi.

Write today for Bulletin E-3560

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / Rochester, England

BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIPMENT COMPANY, CORAOPOLIS, PA.

FISHER®

SINCE 1880

CPI NEWS BRIEFS . . .
(continued from page 56)

at Monsanto, Ill., to make esters for broadleaf weed and brush control.

Du Pont will build a multimillion-dollar plant at Tonawanda, N. Y., to produce a newly developed polyvinyl-fluoride-base industrial film. Facility is scheduled to start production in mid-1962, will be operated as a unit of the firm's Yerkes Film Plant at Tonawanda.

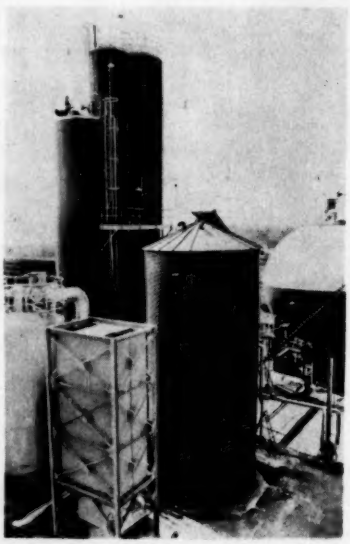
W. R. Grace & Co. has announced that its Polymer Chemicals Div. will undergo a major expansion program in the plastics field. Capacity of the division's high-density-polyethylene plant at Baton Rouge, La., will be increased by 50%, and additions will be made to the division's slate of polystyrenes and low- and medium-density polyethylenes.

The company's polystyrene resins are made by Cosden Petroleum Corp., Big Spring, Tex., a W. R. Grace subsidiary since last winter. The low- and medium-density polyethylenes are produced for Grace by U.S. Industrial Chemicals Co., at Houston.

The Borden Co. and **U.S. Rubber Co.** have bought an 850-acre site near Geismar, La., in the greater Baton Rouge area, for construction of their forthcoming $50-million joint-venture complex of plants to process hydrocarbon raw materials. A company named Monochem, Inc., will be formed through the venture; it will build a plant to produce acetylene and vinyl chloride monomer, which in turn will be further processed by the parent companies at plants they will build adjacent to the Monochem facility. The complex is scheduled for completion in 1962.

Kaiser Aluminum & Chemical Corp. is spending about $2 million to expand facilities for producing extrusion billets of aluminum at Chalmette, La., where the firm operates a primary reduction plant. Project includes holding and charging furnaces, a high-capacity, direct-chill casting unit and accessory equipment. Kaiser states that the completed facility will be the largest and most versatile of its type at any primary aluminum plant in the U.S.

W. R. Grace & Co. reports that its Dewey & Almy Chemical Div. will start making an additional, undisclosed product at its Owensboro, Ky., plant. Dedicated in June, 1959, the plant currently produces synthetic rubber, polyvinyl acetate emulsion and battery separators. Installation of equipment to make the new product will cost about $1 million.



Linde Co., Div. of Union Carbide Corp., recently started up an on-site oxygen plant for Great Lakes Steel Corp., at Ecorse, Mich. Unit, shown above, is rated at 500 tons/day. Tall interchanger section, background, contains a heat exchanger and a fractionating column for separating oxygen from air. Equipment in foreground includes a reversing heat exchanger, a nitrogen regenerator, a silencer, an insulation silo and a liquid-oxygen storage sphere.

Reichhold Chemicals, Inc., will build a combination processing unit to make polyester and alkyd resins at the firm's plant-site in Jacksonville, Fla. The new unit will cost

G-B SNAP*ON DISTRIBUTORS

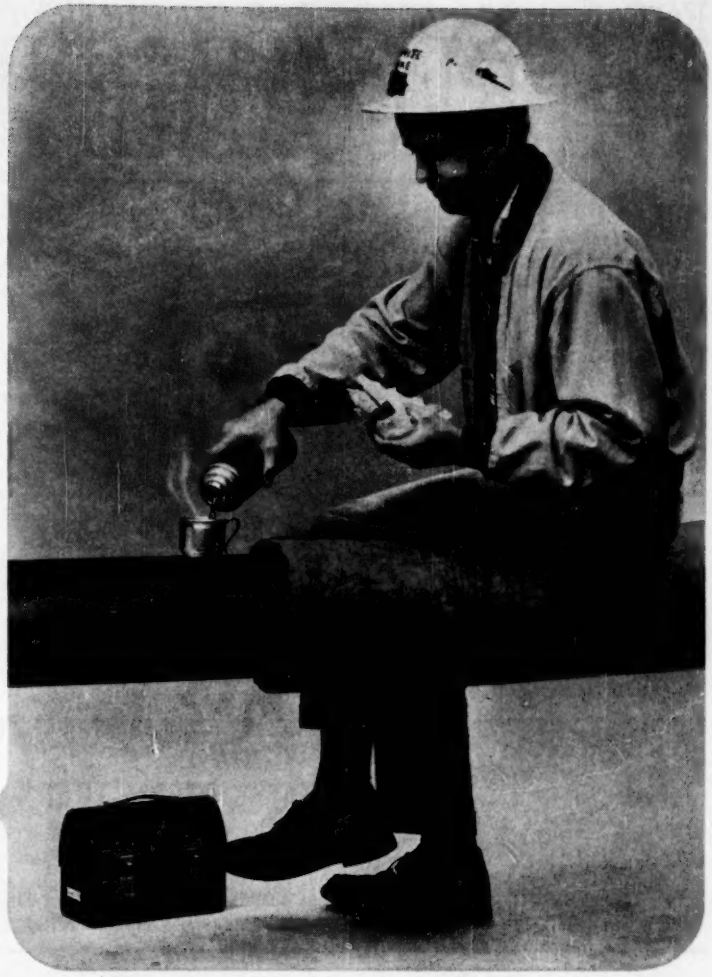
LISTED IN YELLOW PAGES

AKRON, Ohio, The Asbestos Supply Co.
ALBANY, Ga., Industry Insulation Co.
ALBANY, N. Y., Hudson Valley Asbestos Corp.
ALBUQUERQUE, N. M., Mt. States Insulation Co.
AMARILLO, Tex., McDonald Engineering & Insulating Co.
ATLANTA, Ga., Reynolds Aluminum Supply Co.
AUSTIN, Tex., Cinbar Engineering Co.
BALTIMORE, Md., Leroy Insulation Co.
BANGOR, Me., Eastern Glass Co.
BATON ROUGE, La., Eagle Asbestos & Packing Co.
BEAUMONT, Tex., Coburn Supply Co., Inc.
BILLINGS, Mont., Big Horn Supply, Inc.
BIRMINGHAM, Ala., Reynolds Aluminum Supply Co.
Shook & Fletcher Supply Co.
BORGER, Tex., Western Chemical & Supply Co.
BOSTON, Mass., Homans-Kohler, Inc.
BRIDGEPORT, Conn., Robert A. Keasbey Co., Inc.
BRUNSWICK, Ga., Baker Bros., Inc.
BUFFALO, N. Y., Industrial Insulation Sales, Inc.
BURLINGTON, Vt., Pipe Insulators, Inc.
CHAMPAIGN, Ill., The Lewie-David Co.
CHARLESTON, S. C., Baker Bros., Inc.
CHARLESTON, W. Va., Asbestos & Insulating Co.
CHARLOTTE, N. C., D & B Insulation Co.
CHICAGO, Ill., E.C. Carlson Co.
Culberg Asbestos & Cork Co.
CHRISTOPHER, Ill., Hoe Supply Co.
CINCINNATI, Ohio, R. E. Kramig Co.
CLEVELAND, Ohio, Ohio Asbestos & Insulation Co.
COLUMBIA, S. C., Industrial Insulation Div. of
Richland Oil Co.
COLUMBUS, Ohio, Santeler Brothers
Culberg of Ohio
CORPUS CHRISTI, Tex., Precision Insulation Co.
DALLAS, Tex., Acme Insulation & Supply Co.
DAVENPORT, Iowa, Republic Electric Co.
DAYTONA BEACH, Fla., B & F Insulation Co.
DECATUR, Ill., The Lewie-David Co.
DENVER, Colo., Plateau Supply Co.
Powers Industrial Insulation, Inc.
DES MOINES, Iowa, Iowa Asbestos Company, Inc.
DETROIT, Mich., The Walter Rankin Co.
ERIE, Pa., Laco-McMullen Co.
EVANSVILLE, Ind., Geo. Koch Sons, Inc.
FALCONER, N. Y., Laco Roofing
FT. SMITH, Ark., Gunn Distributing Co.
FT. WAYNE, Ind., M. H. Hilt, Inc.
FT. WORTH, Tex., Bracken Co.
GAINESVILLE, Fla., Baker Bros., Inc.
GRAND RAPIDS, Mich., M. S. Knee Co.
GREENSBORO, N. C., Starr Davis Co., Inc.
GULFPORT, Miss., Paine Supply Co.
HONOLULU, Hawaii, Parker Fallis Insulation Co., Inc.
HOUSTON, Tex., Precision Insulation Co.
INDIANAPOLIS, Ind., Lyon Lumber & Supply Co.
JACKSON, Miss., Paine Refrigeration Supply Co.
JACKSONVILLE, Fla., Baker Bros., Inc.
Eckles Distributors, Inc.
Reynolds Aluminum Supply Co.
JOPLIN, Mo., Joplin Cement Co.
KANSAS CITY, Mo., Central Supply Co.
Insulation & Acoustical Specialites Co., Inc.
Kelley Asbestos Prod.
KEWANEE, Ill., Mechanical Insulation Co., Inc.
LAKE CHARLES, La., Coburn Supply Co., Inc.
Solar Supply Co.
LITTLE ROCK, Ark., Gunn Distributing Co.
LOS ANGELES, Calif., Accurate Insulation Co., Inc.
Western Fibrous Glass Products Co.
LOUISVILLE, Ky., General Insulation & Roofing Co.
MACON, Ga., Industry Insulation Co.
MARIETTA, Ohio, Asbestos & Insulating Co.
MEMPHIS, Tenn., Gibbons Supply Co.
MIAMI, Fla., Reynolds Aluminum Supply Co.
Southern Metal Products Co.
MILWAUKEE, Wisc., F. R. Dengel Co.
MINNEAPOLIS, Minn., Asbestos Products, Inc.
MOORHEAD, Minn., Fargo-Moorhead Insulation Co.
NASHVILLE, Tenn., Reynolds Aluminum Supply Co.
NEWARK, N. J., Eastern Steam Specialty Co.
Robert A. Keasbey Co., Inc.
NEW ORLEANS, La., Eagle Asbestos & Packing Co.
NEW YORK, N. Y., Eastern Steam Specialty Co.
Robert A. Keasbey Co., Inc.
OKLA. CITY, Okla., Ball Distributing & Engineering Co.
OMAHA, Nebr., Cardinal Supply & Mfg. Co.
ORANGE, Conn., Insulation Supply Co.
ORLANDO, Fla., Baker Bros., Inc.
PADUCAH, Ky., Triangle Insulation Co.
PHILADELPHIA, Pa., John F. Scanlan, Inc.
PHOENIX, Ariz., Williams Insulation Co.
PITTSBURGH, Pa., Dravo Corp., Keystone Div.
PORTLAND, Me., Eastern Glass Co.
PORTLAND, Ore., Western Fibrous Glass Products Co.
RALEIGH, N. C., Reynolds Aluminum Supply Co.
RAPID CITY, S. D., Robbins & Stearns Wholesale
RICHMOND, Va., Reynolds Aluminum Supply Co.
ROANOKE, Va., C. E. Thurston Co.
ROCKFORD, Ill., Mott Brothers Co.
SALT LAKE CITY, Utah, Bullough Asbestos Supply Co.
SAN ANTONIO, Tex., San Antonio Machine & Supply Co.
SAN DIEGO, Calif., Western Fibrous Glass Products Co.
SAN FRANCISCO, Calif., Western Fibrous Glass Products Co.
SAVANNAH, Ga., Baker Bros., Inc.
Reynolds Aluminum Supply Co.
SEATTLE, Wash., Western Fibrous Glass Products Co.
SHREVEPORT, La., Frith Sales Co.
SOMERVILLE, Mass., Insulation Products, Inc.
ST. LOUIS, Mo., Refrigeration Supplies, Inc.
The Stovey Company, Inc.
ST. PAUL, Minn., Asbestos Products, Inc.
SYRACUSE, N. Y., Burnett Process, Inc.
TALLAHASSEE, Fla., Baker Bros., Inc.
TAMPA, Fla., Eagle Roofing & Art Metal Works, Inc.
TULSA, Okla., Ball Distributing & Engr. Co.
TUPELO, Miss., Paine Supply Co.
VALDOSTA, Ga., Baker Bros., Inc.
WASHINGTON, D. C., Walter E. Campbell Co., Inc.
WEST PALM BEACH, Fla., Southern Metal Prod.
WICHITA, Kans., General Metals, Inc.

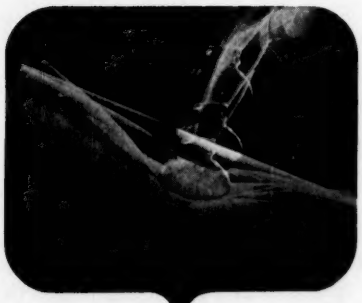
S*O 11/30/60

HERE'S WHY G-B SNAP*ON® GLASS FIBER PIPE INSULATION OUT-PERFORMS ALL OTHER PIPE COVERINGS

FOR CHILLED AND HEATED PIPE FROM SUB-ZERO TO 350° F.—INDOORS OR OUT— G-B SNAP*ON HAS NO SUPERIOR. AND HERE'S WHY:

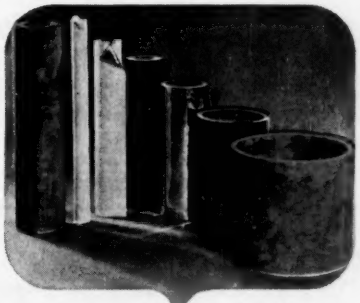


HIGH IN THERMAL EFFICIENCY. A heated pipe may keep this workman's coffee hot, but it's a cinch that he won't get a "hot seat" when he's protected by G-B Snap*On. The "K" factors of this all-glass-fiber insulation are second to none among all general purpose pipe insulations.



IMMUNE TO DAMAGE. Tough to beat and tough to abuse — that's G-B Snap*On. There's just no knocking out the highly resilient glass fibers that go into the construction of G-B Snap*On. Even when accidentally crushed or stepped on, it springs back to its original shape.

EASY, FAST TO INSTALL. Thanks to its snap-hinge action, G-B Snap*On slips over pipe and snaps back to its original cylindrical shape in one easy motion. Once in place, G-B Snap*On provides permanent insulation protection. It does not rot, corrode, mildew or otherwise deteriorate.



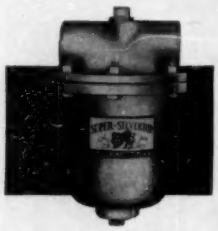
VARIETY OF SIZES. The only one-piece glass fiber pipe insulation available in sizes over 32" IPS, G-B Snap*On is also available in diameters down to copper tubing . . . varying thicknesses . . . plain or with a variety of factory-applied facings for use indoors or out.

WRITE FOR COMPLETE PRODUCT INFORMATION

GUSTIN-BACON *Manufacturing Company* GUSTIN gb® BACON

252 W. TENTH ST., KANSAS CITY, MO.

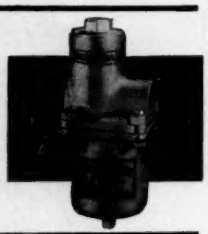
FOR STEAM PROCESS EFFICIENCY
WE RECOMMEND



Super-Silvertop
INVERTED BUCKET TRAPS for:

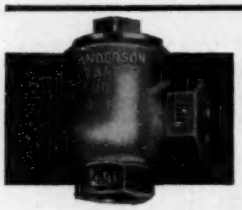
Autoclaves
Bare Pipe
Calenders
Coffee Urns
Convectors
Corrugated Paper Making Machines
Drain Pans
Dress Forms
Drips
Dry Cans
Dryers
Fan Systems
Flat Work Ironers
Header Drips
Hot Water Heaters
Kettles
Pipe Coils
Presses
Sock Forms
Steam Engines
Steam Mains
Steam Tables
Steam Purifiers
Sterilizers
Submerged Surfaces
Tumblers
Unit Heaters
Vacuum Canners
Warmers

Heat-Kwik
COMBINATION TRAPS for:



Autoclaves
Cooking Kettles
Dryers
Expellers
Kettles
Rendering Cookers
Retorts
Slashers
Submerged Surfaces
Tempering Apparatus
Unit Heaters
Water Heaters

or wherever fast heating up is desired

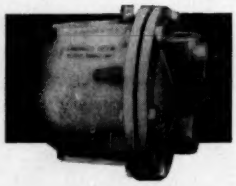


Quik-Flex
THERMOSTATIC STEAM TRAPS for:

Autoclaves
Cooking Kettles
Dryers
Expellers
Kettles
Retorts
Slashers
Sterilizers

or wherever fast heating up, or outside freeze-proof installations are required.

Anderson
FLOAT TRAPS for:



Air Purifiers
Gas Purifiers
Condensate Flow Meters
False Water Line Sewers
Master Trapping Separators
Air Separators
Gas Separators
Air Receivers
Gas Receivers
Gas Scrubbers

or wherever continuous discharge is necessary

Anderson has no "axe" to grind. With a complete line of traps we provide an honest recommendation for all your trap problems. Write for your free book "How to Select Steam Traps" . . . written to give you an unbiased opinion in answer to all your steam trap difficulties.

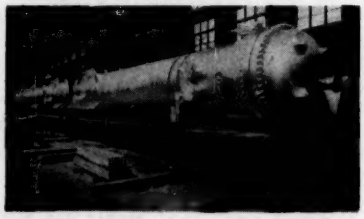
SUPER SILVERTOPS STEAM TRAPS
BY THE MANUFACTURERS OF Hi-eF PURIFIERS

THE V. D. ANDERSON COMPANY
Division of International Basic Economy Corporation
1943 West 96th Street • Cleveland 2, Ohio

CPI NEWS BRIEFS . . .

about $500,000, will have annual capacity of 10 million lb.

Olin Mathieson Chemical Corp. has completed a gas scrubbing unit at its Beaumont, Tex., sulfuric acid plant. New facility will remove sulfur dioxide from off-gases, will use it as raw material to make ammonium sulfate.



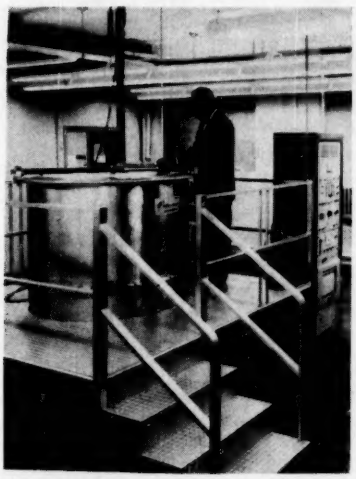
Bethlehem Steel Co. is installing a 110-ton/day experimental unit at its Los Angeles works to produce iron by the H-Iron process. Developed jointly by Bethlehem and by Hydrocarbon Research, Inc., New York, process yields the metal directly from ore by reduction with hydrogen (*Chem. Eng.*, Feb. 8, 1960, p. 96). Heart of Bethlehem's new unit is the 141-ton pressure vessel seen above, in which the reduction reaction will take place in a fluidized bed. Main advantage of the new process, which is also used in a 50-ton/day plan of Alan Wood Steel Co. at Conshohocken, Pa., is that it eliminates the need for coke—the hydrogen is provided by natural gas or fuel oil.

Air Reduction Sales Co. will triple the capacity of its air separation plant at Acton, Mass. Expanded plant will be able to produce a total of over 200 tons/day oxygen, nitrogen and argon. Although the original plant cost $9 million, a new engineering technique developed by the firm will permit the expansion to be achieved for only $5.5 million. The new technique reduces the amount of nitrogen recycled during the process, through use of more dryers and refrigeration units.

Foote Mineral Co., Philadelphia, has begun construction of a butyl lithium plant in New Johnsonville, Tenn. It will have capacity of 100,-

000 lb./yr. n-butyl lithium, readily expandable to twice that figure if the market increases. Facility will be able to produce other lithium alkyls as well. Erection of the main building at the new site was begun in October by Foster & Creighton Inc., Nashville, Tenn., and completion is expected within a few months. Plant will augment existing semicommercial facilities that Foote now operates at Exton, Pa.

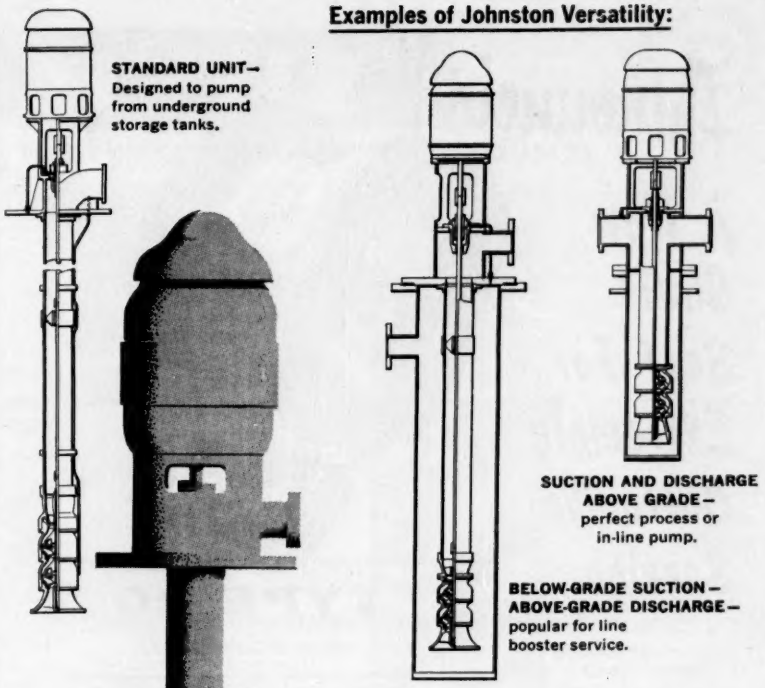
Food Machinery & Chemical Corp. has upped production capacity for its polyolefin-based Oxiron epoxy resins (*Chem. Eng.*, Feb. 22, 1960, p. 56) to semicommercial scale. No new plants have gone up, but FMC's Baltimore, Md., facility has been substantially expanded and modified by addition of new equipment. Unit can turn out other epoxies as well as the Oxirons.



Northeastern University has expanded its nuclear laboratory facilities at Boston by installing a subcritical reactor and a reactor simulator. Reactor, pictured above, produces a low level of fission but cannot produce a self-sustaining atomic reaction. The new simulator, developed by Minneapolis-Honeywell Regulator Co., electronically creates effects identical to those of an actual reactor, thus permits students to gain operating experience and to study problems inherent in live reactors.

Pfaudler Co., division of Pfaudler Permutit Inc., has begun a $1-mil-

Examples of Johnston Versatility:



STANDARD UNIT— Designed to pump from underground storage tanks.

SUCTION AND DISCHARGE ABOVE GRADE— perfect process or in-line pump.

BELOW-GRADE SUCTION— ABOVE-GRADE DISCHARGE— popular for line booster service.

VERSATILE VERTICALS BY JOHNSTON FOR VOLATILE FLUIDS

GASOLINE - CRUDE OIL - AMMONIA - L-P GASES PIPE LINES - REFINERIES - AIRPORTS

Can be designed to operate with zero suction head and/or net positive suction head.

COMBINATION TURBINE-PROPELLER STRIPPING PUMP— maximum suction lift without vapor lock.

WET PIT BOOSTER, TRANSFER OR CIRCULATING PUMP— no expensive priming device necessary.

DIRECT DISPENSING— For transfer of volatile liquids and chemicals.

UNLIMITED FLEXIBILITY—Johnstons fit any piping layout—satisfy virtually all pumping requirements.

CHECK THESE OTHER FEATURES: Economy of higher speeds; Non-overloading power characteristics; Steep head-capacity stability.

For complete details and typical applications, write for colorful bulletin.

Versatile Verticals by

JOHNSTON PUMP COMPANY

A DIVISION OF THE YOUNGSTOWN SHEET AND TUBE COMPANY

3272 E. Foothill Blvd., Pasadena, California

A new shaft seal to handle the most corrosive service conditions has been recently added to the John Crane line. Here's a seal that will stand up under all conditions of acids and salts, oxidizing agents and organic compounds.

It is so designed that all parts that normally contact the fluid are made of chemically-inert DuPont Teflon. Also, for this same reason it can be operated over wide temperature range up to 250° F.

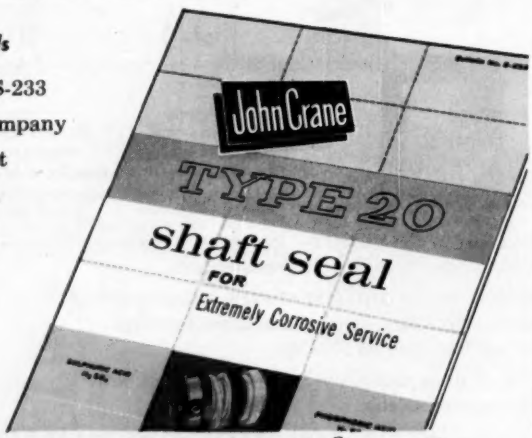
Mechanically, its bellows type construction readily adapts it for use in all non-abrasive slurry applications. It also compensates for extreme shaft run out.

Available in single face construction for internal or external mounting, double face for internal mounting.

Full range of shaft sizes from ⅜" to 3".

Get Complete Details

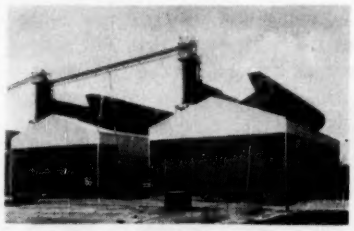
Request Bulletin S-233
Crane Packing Company
6451 Oakton Street
Morton Grove, Ill.
(Chicago Suburb)
In Canada:
Crane Packing
Company, Ltd.
Hamilton, Ont.



CRANE PACKING COMPANY

lion plant expansion in Rochester, N. Y. Main new item is to be a $350,000 gas furnace, for making glassed-steel process equipment weighing up to 50 tons. The 75-ft.-high furnace will be the largest of its kind in the U. S., claims Pfaudler; it will be mounted on stilts to allow bottom-loading.

Food Machinery & Chemical Corp.'s Niagara Chemical Div. will build a new plant in Opelousas, La., to make agricultural pesticides. Facility is scheduled for completion next month; it will contain over 16,000 sq. ft. of space, will produce a number of insecticide and miticide formulations, including DDT and ethion.



Owens-Corning Fiberglas Corp. has started initial operations in a new, multimillion-dolar textile yarn plant at Aiken, S. C. It occupies a 350-acre site, will have a production capacity of 70 million lb./yr. Each of the building wings shown above contains five direct melt furnaces.

Offices

Copolymer Rubber & Chemical Corp. directors have approved plans for a new $750,000 office building at the firm's Baton Rouge, La., headquarters. It will contain 25,000 sq. ft. floor space, is due for occupancy around the end of this year.

International Minerals & Chemical, S. A., subsidiary of International Minerals & Chemical Corp., Skokie, Ill., has completed a new overseas sales office in Puerto Rico. Located in Santurce, just outside San Juan, it will serve as headquarters for IMC sales to cus-

tomers in Latin America and the Far East.

Roger Williams Technical & Economic Services, Inc., a firm that specializes in consultant chemical market research, announces the opening of an office in **Geneva,** Switzerland. Company has headquarters at Princeton, N. J.; other branch offices are in New York, Toronto and London.

Companies

Beryllium Resources, Inc.'s and Dynamic Metals Corp.'s boards of directors have voted in favor of merging, with the former to be the surviving company. Beryllium Resources is active in exploration and development of beryllium ores; Dynamic Metals has developed a new flotation process to concentrate beryllium minerals. Brush Beryllium Co., Cleveland, will acquire an interest in the merged company.

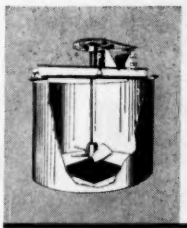
Dow Chemical Co. is acquiring the the assets of Allied Laboratories, Inc., Kansas City. Allied produces pharmaceutical, biological, cosmetic and other products, has plants at Indianapolis and Zionsville, Ind., Sioux Falls, S. D., and Batavia, Ill. It will continue to operate as a division of Dow, and no changes are planned in personnel or in operating plans.

International Minerals & Chemical Corp. is acquiring Bioferm Corp., a producer of chemicals through fermentation. Bioferm will operate under its own name as part of IMC's Amino Div.; the company's plant is in Wasco, Calif.

Atomics International, a division of North American Aviation, Inc., is forming an Energy Conversion Dept., which will work mainly in the field of generating electricity directly from heat without use of rotating machinery. It will be responsible for projects concerning thermionic devices, lightweight batteries and fuel cells, which are

DENVER *equipment*

FOR THE CHEMICAL PROCESS INDUSTRY

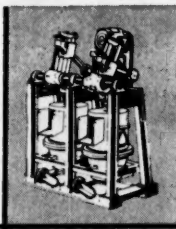


DENVER AGITATORS AND MIXERS

Agitator types available: Turbine-type propeller (to 120" in tanks to 50' dia.), slow speed, high speed, air lift, vertical turbine mixers, mixer-settler units.

Write for Bulletin No. A2-B2

Lab and pilot scale agitators in LG3-B10



DENVER DIAPHRAGM PUMPS

Stroke can be adjusted while pump is operating. Long wearing nylon-reinforced rubber diaphragm. Sizes 1" to 10" simplex and duplex, capacity to 1000 g.p.m.

Write for Bulletin No. P8-B12

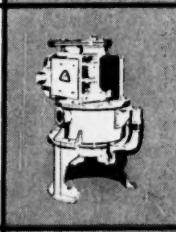
Lab and pilot scale diaphragm pumps in LG3-B10

DENVER ATTRITION SCRUBBERS

High power input to efficiently remove sand coatings, mix dense slurries. Rubber lined or acid-proof tanks. Sizes to 56"x 56"

Write for Bulletin No. A-B505

Lab and pilot scale scrubbers in LG3-B10

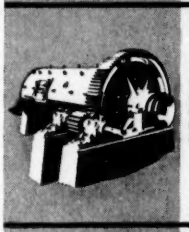


DENVER VERTICAL CENTRIFUGAL PUMPS

For handling frothy liquids or coarse, sandy slurries, constant or intermittent flow. No packing gland or sealing water. Standard or stainless steel construction. Capacity to 450 g.p.m.

Write for Bulletin No. P10-B5

Lab and pilot scale vertical centrifugal pumps in LG3-B10

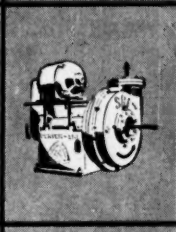


DENVER BALL AND ROD MILLS

Offer operation and convertibility. Wet or dry grinding systems. All steel construction. Ceramic or rubber linings available. Sizes to 10'x 20'.

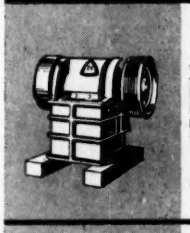
Write for Bulletin No. B2-B20

Lab and pilot scale mills in LG3-B10



DENVER SRL (RUBBER LINED) PUMPS

High efficiency, low horsepower. Parts last longer, cost less. Rubber lined. PUMPS AND PARTS IN STOCK. Sizes to 5000 g.p.m. Now available in "TRU-GLANDLESS" construction. No sealing water. No packing glands. No slurry dilution. **Bulletin P9-B28.**

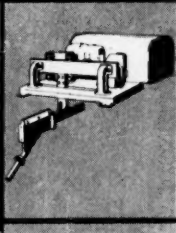


DENVER JAW CRUSHERS

Cast steel frame, anti-friction side bearings and bumper bearings. Manganese steel jaw and cheek plates. Sizes from 2¼"x 3½" to 36"x 48".

Write for Bulletin No. C12-B12

Lab and pilot scale crushers in LG3-B10



DENVER SAMPLERS

Continuous mechanical and automatic types for dry, solution or slurry sampling. Complete sampling plants and sample processing equipment. SAMPLERS IN STOCK.

Write for Bulletin No. S1-B4

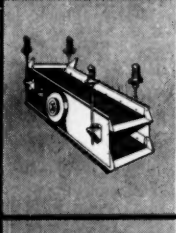
Lab and pilot scale samplers in LG3-B10

DENVER REAGENT FEEDERS

Both wet and dry feeders available. Let us know your requirements. Many standard units in stock.

Write for Bulletin No. F6-B8

Lab and pilot scale feeders in LG3-B10

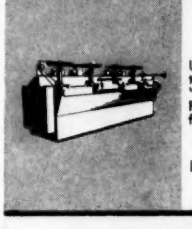


DENVER-DILLON SCREENS

For efficient wet or dry screening. "True-Circle" eccentric action. Sizes to 6'x 14' in stock. Also Trommel Screens in sizes from 30"x 60"x 120".

Write for Bulletin No. S3-B15

Lab and pilot scale screens in LG3-B10

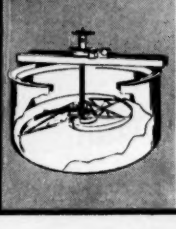


DENVER "SUB-A" FLOTATION

Universal tank with three types of mechanisms: (a) "Cell-to-Cell"; (b) "Free-Flow"; (c) Type "M". Sizes from 16"x 16" to 72"x 72".

Write for Bulletin No. F10-B86

Lab and pilot scale flotation in LG3-B10



DENVER SPIRAL RAKE THICKENERS

Move settled materials to center in one revolution. Simple, efficient, heavy-duty gear mechanism for thickeners to 150' dia. Acid proof construction available.

Write for Bulletin No. T5-B6

Lab & pilot scale thickeners in LG3-B10

DENVER EQUIPMENT COMPANY

Box 5268, Denver 17, Colorado

Phone CHerry 4-4466

SEE OUR CATALOG ON PAGES 949-956 IN C.E.C.

DENVER TESTING FACILITIES

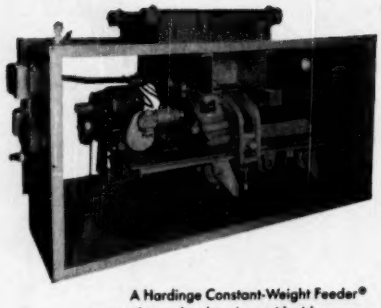
You will have problems in crushing, grinding, settling and possibly concentration and filtering. These are our specialties so please let us help you in our Test Department. Our flowsheets are reliable and proven.

looking toward
IMPROVED PRODUCTION
... look to Hardinge !

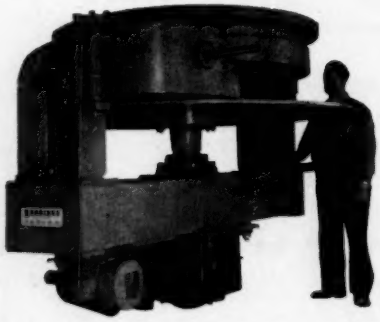
HARDINGE FEEDERS

Hardinge Feeders are available in sizes and types to meet your specific requirements. Constant-Weight Feeders, Volumetric Belt Feeders, Disc Feeders and Rotary Pocket Feeders are offered. All Hardinge Feeders are suspended from feed bins or tracks and need little head room. Costly feeder support structures are unnecessary; equipment following the feeder is readily accessible. When track-mounted, one Hardinge Feeder may serve a number of bins, intermittently.

For the Hardinge Feeder story, with drawings, photos and detailed specifications, ask for 12-page bulletin No. 33-E-11.



A Hardinge Constant-Weight Feeder® mounted in a dust housing, with side covers removed. Observation windows are provided in covers. Note track-mounting wheels at top.



84-inch diameter Hardinge Disc Feeder for installation in a lime and cement plant.

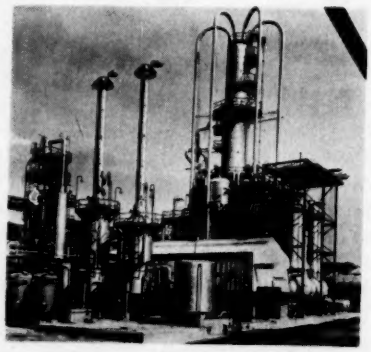
Extra-long (96 inch) conveyor type Hardinge Volumetric Belt Feeder designed for bin mounting.

HARDINGE
COMPANY, INCORPORATED
Main Office and Works • 240 Arch St., York, Pa.
"Hardinge Equipment—Built Better to Last Longer."

NEW YORK
TORONTO
CHICAGO
HIBBING
SALT LAKE CITY
SAN FRANCISCO
HOUSTON
LAKELAND
BIRMINGHAM

now being conducted by Atomics International.

Owens-Corning Fiberglas Corp. has acquired a substantial minority interest in Fibreglass South Africa (Pty.) Ltd., manufacturer of thermal insulation products. Other shareholders are Plate Glass & Shatterprufe Industries, of South Africa, and Fibreglass, Ltd., of Great Britain.



Italy: Badger Mfg. Co., Cambridge, Mass., recently completed the 22-million-lb./yr. phthalic anhydride plant shown above for ACNA (Aziende Colori Nazionali Affini), a Montecatini subsidiary, at Cengio, Italy. Facility is said to be the largest phthalic anhydride unit in Italy and the first to use a fluid bed catalytic process.

Canada: British American Oil Co. has placed a 15-million-cu. ft./day gas plant on stream near Gilby, Alta. Known as a dry-desiccant, short-cycle gas dehydration and hydrocarbon recovery unit, it consists of a three-tower absorption unit with condensate stabilizer column and open regeneration circuit. It is said to be one of 20 or more small, prefabricated units that various firms will build in western Canada before the end of this year.

International

Canada: The Borden Chemical Co. (Canada) Ltd. is spending $250,000 on facilities in Ontario to

make polyvinyl acetate emulsions, polystyrene and acrylic emulsions and liquid-urea resins. Program is scheduled to be completed early in 1961.

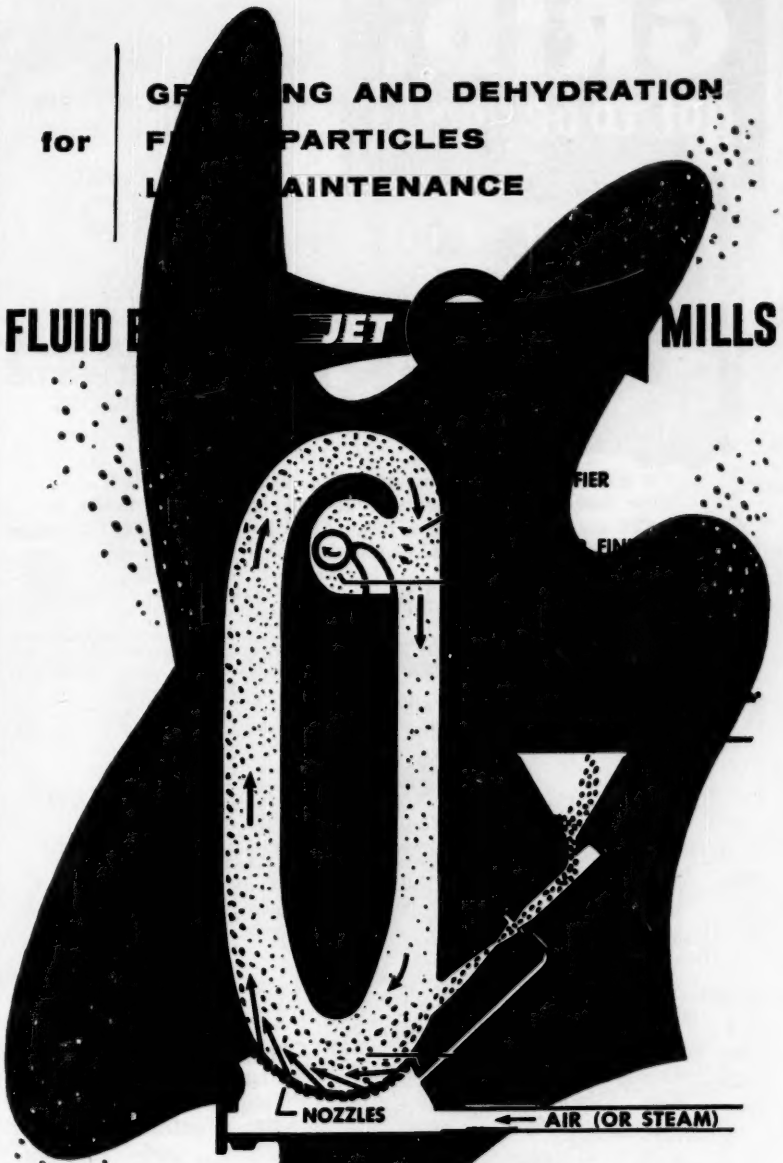
West Germany: Farbwerke Hoechst AG, Frankfurt/Main–Hoechst, will invest $1 million to expand wax capacity at its Gersthofen facilities situated near Munich.

Nigeria's government and the Shell-BP Petroleum Development Co. of Nigeria have reached an agreement in principle that Shell and British Petroleum should jointly build a refinery in that country. Proposed facility will cost about $33.6 million, will be Nigeria's first refinery. Location will probably be in the Port Harcourt area, and crude capacity will be about 20,000 bbl./day. The refinery will process Nigerian crude into refined products for the local market; it is expected to be on stream in 1963 or 1964.

Australia: Kaiser Aluminum & Chemical Corp. and Consolidated Zinc Corp. Ltd. will jointly establish a new aluminum complex in Australia and New Zealand. Project will include (1) development of bauxite reserves near Weipa, on Cape York Peninsula, Australia, (2) construction of a 360,000-long ton/yr. alumina refinery at Weipa, (3) expansion of primary aluminum capacity at Bell Bay, Tasmania, from 12,000 to at least 28,000 long tons/yr., (4) development of a hydroelectric power source in New Zealand, (5) construction of a reduction works to produce 120,000 long tons/yr. of primary aluminum at Bluff, New Zealand, and (6) establishment of fabricating facilities.

Kaiser will invest over $10 million during 1961 on the project, developing and expanding properties now owned by Consolidated Zinc. Additional construction will be carried out by the two firms during the next six years. It is reported that the finished complex will constitute the largest integrated aluminum facilities in the Southern Hemisphere.

for



The Fluid Energy "Jet-O- gned and built by the pioneers in fluid energy fine grindi ore than produce fine particles. It controls fineness and prod nity with a narrow distribution range and simultaneously with grinding can dehydrate, coat particles, blend and achieve chemical changes.

Jet-O-Mizer Mills are being used all over the world, processing many types of materials in the following industries:

• Abrasive	• Food	• Pigment	• Wax
• Insecticide	• Mineral	• Plastic	• Metal
• Ceramic	• Pharmaceutical	• Carbon	• Chemical

"Jet-O-Mizing" produces **FINE PARTICLES** ¼ micron average and above **PLUS . . .** Narrow Particle Distribution • Dry, or Controlled Moisture Content • Continuous Operation • Uniformity of End Product • Other Operations with Grinding • No Attritional Heat — No Moving Parts • Low Operating Costs • Low Maintenance

Send for complete information on Fluid Energy's "Jet-O-Mizer" Mills, "Jet-O-Clone" Dust Collectors, and TESTING AND CUSTOM GRINDING services.

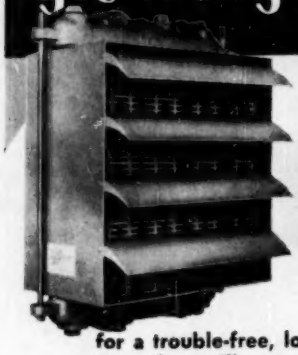
FLUID ENERGY PROCESSING & EQUIPMENT COMPANY

Richmond & Norris Streets, Philadelphia 25, Pa. • Phone: Regent 9-7728

(Formerly known as the Wheeler-Stephanoff Mill)

GRID's got to be good!

The best guarantee any product can have is its users.



LOOK at the plants that depend upon GRID

UNIT HEATERS
BLAST HEATERS
RADIATORS

for a trouble-free, low maintenance cost heating system - One that will serve without service - Installations made in 1929 are still operating without need for repairs. GRID'S design and construction makes the difference!

ABBOTT LABORATORIES — **GRID** — Cast Iron Construction resists corrosion externally from acid fumes and internally from electrolysis. No leaking from rotted cores.

BUCKEYE COTTON OIL CO. — **GRID** — one-piece cast iron heating sections and headers are leak-proof on steam pressure up to 250 p.s.i. 450° temperature. Smaller steam lines cost less.

DIAMOND ALKALI CO. — **GRID** — heating sections with widely spaced fins cast integral with steam chambers are easy to clean - Will not "mat" on air intake side.

ANSUL CHEMICAL CO. — **GRID** — design develops low outlet temperatures and, with proper fan volumes, delivers warm, comfortable air to floor - No wasted heat at ceiling.

Get complete information on a GRID System for your plant. Write for catalog #956 GRID CAST IRON STEAM HEAT TRANSFER SURFACE.

Representatives in principal cities

GIVAUDAN-DELAWANNA CORP.
HOFFMAN LA-ROCHE INC.
NATIONAL LEAD CO.
PENNSYLVANIA SALT MFG. CO.
NATIONAL ANILINE
NOPCO CHEMICAL CO.
CHAS. PFIZER & CO., INC.
HOOKER CHEMICAL CORP.
MONSANTO CHEMICAL CO.
DIAMOND CRYSTAL SALT CO.
NAUGATUCK CHEMICAL
E. I. DuPONT de NEMOURS, INC.
STAUFFER CHEMICAL
COLUMBIA SOUTHERN CHEMICAL CORP.
CHEMICAL & INDUSTRIAL CORP.
MINNESOTA MINING & MFG. CO.
HARSHAW CHEMICAL CO.
UNION CARBIDE & CARBON
VITRO MFG. CO.
HERCULES POWDER
NICHOLS CHEMICAL CO., LTD.
BENZOL PRODUCTS
DOW CHEMICAL CO.
PENICK & FORD LTD.
AMERICAN CYANAMID
SHARPLES CHEMICALS
CLIFFS DOW CHEMICAL CO.
REICHOLD CHEMICAL INC.
DAVISON CHEMICAL CORP.
NATIONAL DISTILLERS PROD. CO.
OLIN MATHIESON CHEMICAL CORP.
KOPPERS CO. INC.
EASTMAN KODAK CO.
LITHIUM CORP. OF AM.
VICTOR CHEMICAL WORKS
AMERICAN VISCOSE CORP.
HOECHST CHEMICAL CO.
MERCK & CO., INC.
SOUTHERN DYESTUFF CORP.
GENERAL ANALINE & CHEMICAL DIV.
HILTON DAVIS CHEMICAL CO.
WITCO CHEMICAL CO.
ALLLIED CHEM. & DYE CORP.
FOOD MACHINERY & CHEMICAL CORP.

D. J. MURRAY MANUFACTURING CO.
WAUSAU *Manufacturers Since 1883* WISCONSIN

CPI NEWS BRIEFS . . .

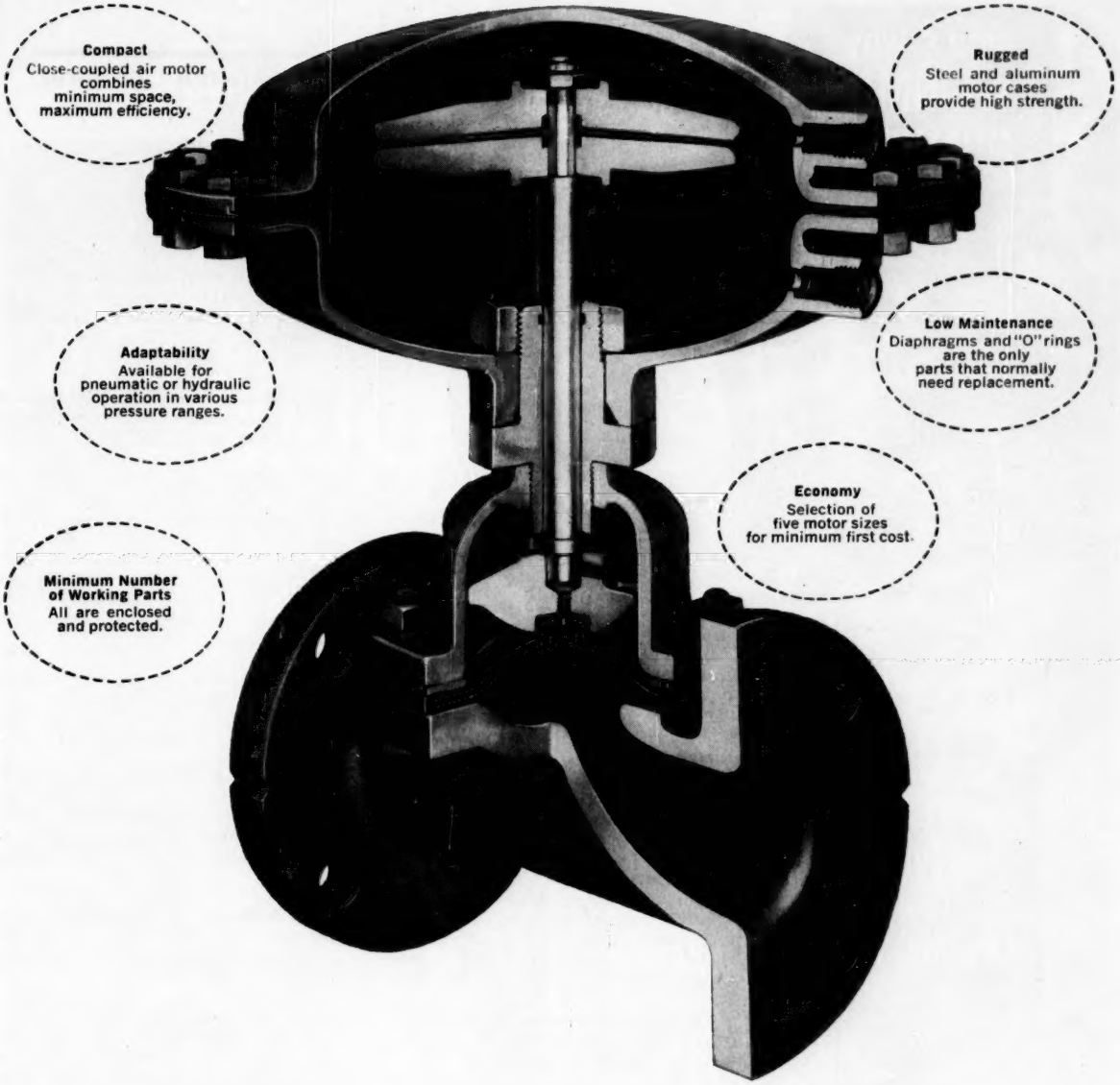
Canada: Alberta West Forest Products Corp. Ltd., Edmonton, will build a $38-million pulp and paper mill in the Whitecourt area, about 100 mi. northwest of Edmonton. Initial output will be 300 tons/day. Construction is scheduled to start in May, and H. K. Ferguson Co., Cleveland, will act as consulting engineers and builders.

England now has its first domestic source of sodium chlorate, following startup of a Laporte Chemicals Ltd. plant at Luton, Bedfordshire. Capacity has not been disclosed, but the company states that its plant will not eliminate need for imports of the salt, supplied by Europe. Facility uses the Kesting process, a method licensed from Elektrochemische Werke Munchen, Munich, Germany.

Italy: Rumianca, S.p.A., Torino, will build an 11,000-ton/yr. plant to make polyvinyl chloride resins at Pieve Vergonte, near Italy's Swiss frontier. It is expected to cost about $3 million, is scheduled for production by mid-1962. Technical information and engineering services for the project will be supplied by United States Rubber Co.'s Naugatuck Chemical Division.

Canada: Ethyl Corp. of Canada Ltd. has a newly completed plant to make ethyl chloride, ethylene dichloride, at Sarnia, Ont. Construction was by Canadian Badger Co. Ltd. Ethyl of Canada will purchase required supplies of ethylene, hydrogen chloride and chlorine locally, will put the new plant units on stream as the raw materials become available.

Japan's government has approved two license agreements between Montecatini, of Italy, and two leading local chemical companies for production of isotactic polypropylene in Japan. Companies involved are Mitsui Chemical Industry Co. and Mitsubishi Petrochemical Co., both of Tokyo. The polypropylene will be used for making transparent films, textile fibers and plastics products.


Compact
Close-coupled air motor combines minimum space, maximum efficiency.
Rugged
Steel and aluminum motor cases provide high strength.
Adaptability
Available for pneumatic or hydraulic operation in various pressure ranges.
Low Maintenance
Diaphragms and "O" rings are the only parts that normally need replacement.
Economy
Selection of five motor sizes for minimum first cost.
Minimum Number of Working Parts
All are enclosed and protected.

Why this power-operated diaphragm valve is so versatile...economical

The Grinnell double-acting air motor teams up with the Grinnell-Saunders Diaphragm Valve to provide a power-operated valve that's versatile and economical! What's more, the "Grinnell" name on each part assures you of the highest quality throughout the completed unit. Available in a range of motor sizes for ½" through 6" valves. Learn how Grinnell power-operated valves can help *your* installation. Write Grinnell Company, Providence 1, R. I.

You get a wide choice of accessories too!

- Handwheel closing device
- Positioner
- Adjustable travel stop
- Adjustable opening stop
- Position indicator
- Microswitches

GRINNELL-SAUNDERS DIAPHRAGM VALVES

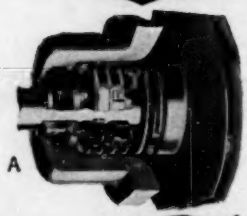
GRINNELL COMPANY, PROVIDENCE 1, R. I. • BRANCH WAREHOUSES AND DISTRIBUTORS FROM COAST TO COAST
PIPE FITTINGS • VALVES • PIPE HANGERS • PREFABRICATED PIPING • UNIT HEATERS • PIPING SPECIALTIES

here's why
WEINMAN
PUMPS

are
preferred
for safe,
swift
handling of
corrosive
liquids...

Chemical engineers rely on Weinman Types GB and KB Single Stage, End Suction Pumps as the standard for safe, positive pumping of all types of liquids. There's good reason for it, too. Designed to exceed industry specifications, Weinman's line of end suction pumps are available in full range of sizes to handle from 10 GPM to 2000 GPM. Rugged construction provides years of low maintenance service under the toughest conditions; heavy duty shafts prevent vibration and deflection; oversize bearings easily handle radial and thrust loads. And, corrosion-resistant metals protect all surfaces exposed to chemical action.

Many Weinman pump features were developed in collaboration with the chemical industry.



A

. . . for example, this special shaft seal (shown at left . . . A) stops chemical leakage; reduces fire hazards; eliminates fumes and cuts waste.

B

. . . and this open type impeller (shown at left . . . B) available for every size pump, speeds pumping of liquids with suspended foreign matter.

If you have a touchy chemical pumping problem... consult your Weinman Specialist. You'll find him in the Yellow Pages. Chances are he can recommend a standard pump that meets your precise need. If not, we'll work with you in solving your problem. Or write us direct for Bulletin 500.

MEMBER

THE WEINMAN PUMP MFG. CO.
290 SPRUCE STREET COLUMBUS 15, OHIO
CENTRIFUGAL SPECIALISTS

Convention Calendar

January

16-18. American Astronautical Society, 7th Annual Meeting and Convention, Sheraton-Dallas Hotel, Dallas.

17-19. Instrument Society of America, Winter Instrument-Automation Conference and Exhibit, Sheraton-Jefferson Hotel and Kiel Auditorium, St. Louis, Mo.

23-26. 12th Annual Plant Maintenance & Engineering Show, International Amphitheatre, Chicago, Ill.

24-27. Society of Plastics Engineers, Annual Technical Conference, Shoreham and Park-Sheraton Hotels, Washington, D. C.

24-27. Canadian Pulp and Paper Assn., 1961 Annual Meeting of the Technical Section, Queen Elizabeth Hotel, Montreal, Que.

30-9. University of Illinois, Quality Control by Statistical Methods, Urbana, Ill.

February

5-10. National Petroleum Assn., Symposium on Research on Gasoline, Benjamin Franklin Hotel, Philadelphia, Pa.

7-9. The Society of the Plastics Industry, Inc., 16th Reinforced Plastics Division Conference, Edgewater Beach Hotel, Chicago, Ill.

13-16. American Society of Heating, Refrigerating and Air-Conditioning Engineers, 15th International Heating & Air-Conditioning Exposition, Chicago Amphitheatre, Chicago, Ill.

13-17. American Management Assn., Inc., Packaging Management Course, Hotel Astor, New York, N. Y.

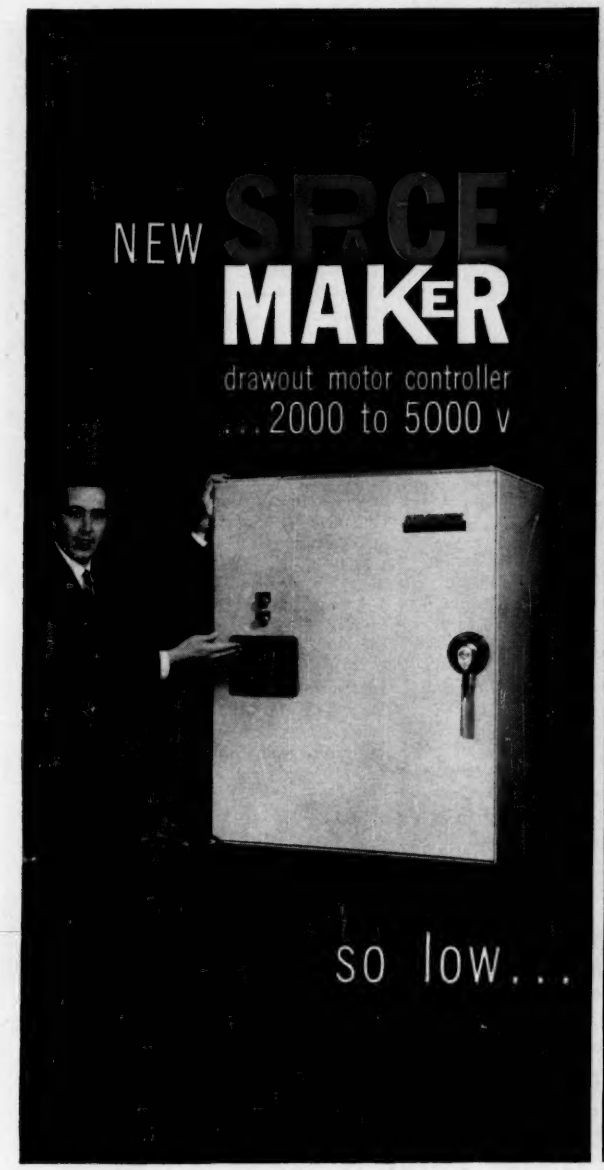
16-17. American Society for Metals (Albuquerque and Los Alamos Chapters), Symposium on Recent Developments in Materials for Nuclear Applications, University of New Mexico, Albuquerque, N. M.

20-23. Technical Assn. of the Pulp and Paper Industry, 46th Annual Meeting, Hotel Commodore, New York, N. Y.

26-2. Society of Petroleum Engineers of the American Institute of Mechanical Engineers, Annual Meeting, Chase & Park Plaza Hotels, St. Louis, Mo.

26-1. American Institute of Chemical Engineers, Petroleum and Petrochemical Exposition, National Meeting, Municipal Auditorium, New Orleans, La.

ALLIS-CHALMERS

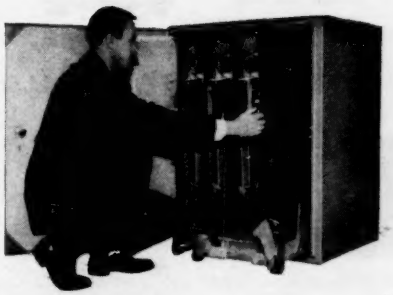


New *SpaceMaker* control is the first completely new high-voltage motor controller in more than a decade. It is the first two-high, 2 to 5 kv control center, and the first in its voltage class with complete drawout construction for unprecedented safety and accessibility.

Inspection and maintenance are greatly simplified. One man can easily roll the carriage from the control enclosure for complete accessibility. Arc chutes and barriers lift out and the pole pieces rotate to expose the contact structure.

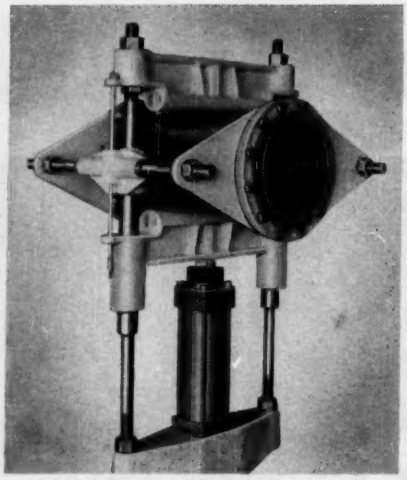
And, *SpaceMaker* control is completely safe. It is impossible to come in contact with "live" parts because the contactor is connected and disconnected with the door closed and live line connections are isolated by automatic shutters.

For complete details of the new, years-ahead SpaceMaker *controller, call your nearby A-C representative. Or write* **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wisconsin.* A-1406



SpaceMaker is an Allis-Chalmers trademark.

AUTOMATED *Hydral-60* PINCH VALVE SYSTEMS



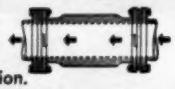
Controlled circuitry for any operating requirements

- The Massco-Grigsby Hydral-60 System consists of one or more pinch valves with a single automatically operated hydraulic pump.
- Hydraulic pump may be operated by electric motor or by air from normal plant supply system.
- Valves may be the same or different size.
- Valves in the system may be operated simultaneously or independently.
- Control valve may be manual or solenoid.
- Valves are self-supporting and may be operated in any position from horizontal to vertical.
- Valves may be coordinated and interlocked with other plant equipment to automatically control tank levels, rate of flow, etc.
- Valves may be independently controlled for normal or rapid closure.
- Valves may be held fully open, fully closed, or at intermediate positions.
- Remote control to meet individual requirements.
- Controls may be included for automatic emergency operation.
- 3" to 14" I.D. sizes, with 50, 100, and 150 psi line pressure ratings.
- Temperatures to 200° F.

Advantages of Massco-Grigsby Pinch Valves

- Rubber, neoprene and special compounded rubber sleeves for corrosive and abrasive pulps and liquids.
- Patented "hinged" sleeve. Recesses serve as "hinges" during compression; reduce strain and permit tight closing.

- Unobstructed flow eliminates high friction loss and prevents contamination.



- Split flanges and patented Flex Seal ends assure perfect seal.
- Rugged, heavy duty construction for most severe service and long life.
- Cannot leak or stick.
- No working parts in contact with pulp or liquid; no packing glands.

WRITE FOR NEW CATALOG NO. 609

The Company that cares enough to give you the best!

MANUFACTURING DIVISION

MINE AND SMELTER SUPPLY CO.

Denver 16, 3800 Race St. | New York 17, 122 E. 42nd St. | Salt Lake City 1, 121 W. 2nd S. | El Paso, 1515 11th Ave. | Albuquerque, 701 Haines N.W.

LICENSED MANUFACTURERS AND SALES AGENTS in Canada, Australia, Sweden, England, South Africa
Sales Agents in Mexico, Peru, Chile, Philippine Islands, Japan, New York City (for Continental Europe) and in principal cities of the U. S.

CALENDAR . . .

March

5-9. The American Society of Mechanical Engineers and The U. S. Department of Defense, 6th Annual Gas Turbine Conference and Products Show, Shoreham Hotel and Pentagon, Washington, D. C.

13-17. National Assn. of Corrosion Engineers, Annual Conference & Corrosion Show, Statler Hotel, Buffalo, N. Y.

15-17. Natural Gasoline Assn. of America, 40th Annual Convention, Baker Hotel, Dallas, Tex.

20-24. American Society of Metals, 12th Western Metal Congress, Ambassadore Hotel, and Western Metal Exposition, Pan-Pacific Auditorium, Los Angeles, Calif.

21-23. Illinois Institute of Technology and American Society of Mechanical Engineers, American Power Conference, Sherman Hotel, Chicago, Ill.

27-29. Midwest Gas Assn., Annual Meeting & Convention, Sheraton-Fontenelle Hotel, Omaha, Neb.

27-31. American Institute of Physics, Instrument Society of America, and National Bureau of Standards, 1961 Symposium on Temperature, Its Measurement and Control in Science and Industry, Columbus, Ohio

April

6-7. American Society of Mechanical Engineers, Management Engineering Conference, Statler-Hilton Hotel, New York, N. Y.

10-11. American Society of Mechanical Engineers, Maintenance & Plant Engineering Conference, Bancroft Hotel, Worcester, Mass.

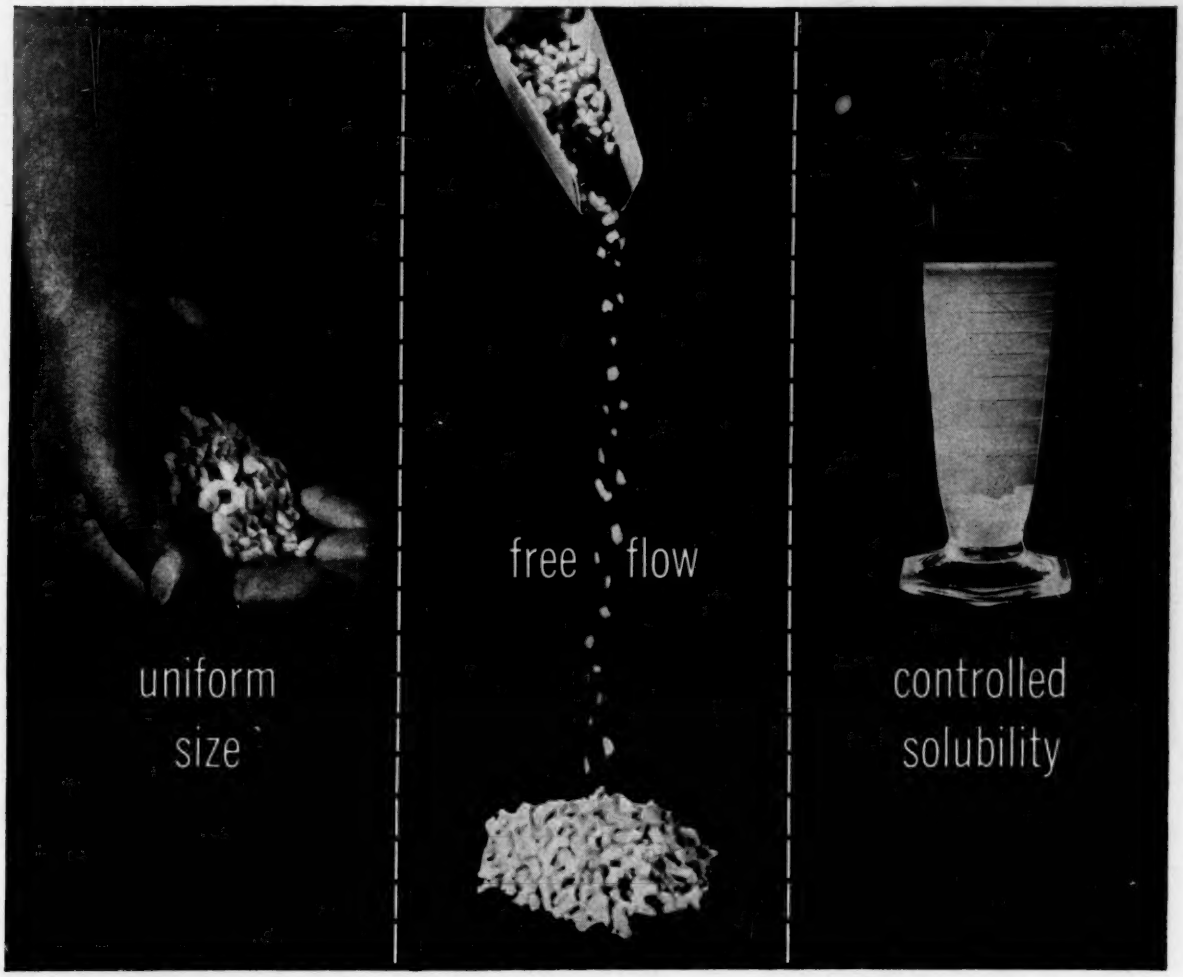
10-11. The Combustion Institute, Western States Section, 1961 Spring Meeting, Aeronutronic, Newport Beach, Calif.

10-12. American Welding Society, 42nd Annual Convention and Welding Exposition, Technical Meetings at Sheraton-Atlantic and Commodore Hotels, Show in New York Coliseum, New York, N. Y.

10-14. Greater New York Safety Council, 31st Annual Safety Convention & Exposition, Statler-Hilton Hotel, New York, N. Y.

11-13. Air Force Research & Development Command, Conference on Ultrapurification of Semiconductor Materials, New England Mutual Hall, Boston, Mass.

ALLIS-CHALMERS



Consistently better product

with this continuous mechanical compacting process

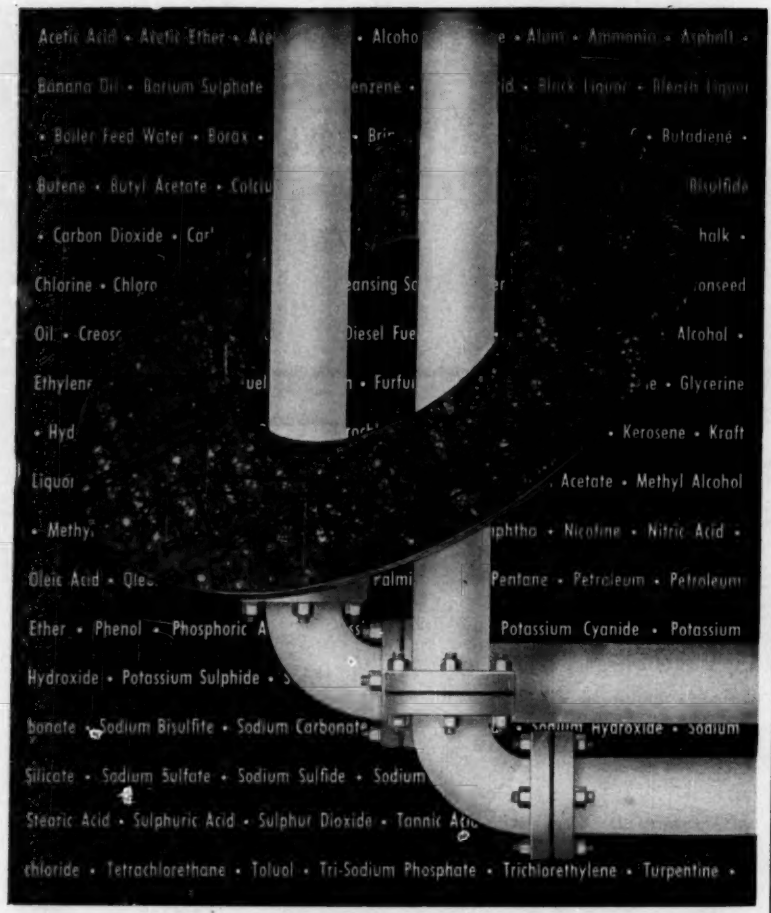
Take your process, step by step, and analyze the physical properties you need for better quality and production control. Somewhere along the line you face problems involving granular size, density, solubility . . . feeds, speeds, control . . . additives, binders, flow properties.

Allis-Chalmers helps you maintain control over all of these variables with a continuous compacting process that's the result of years of engineering experience in the chemical industry.

This process produces granules that are more uniform in size . . . granules that flow freer, won't fracture or abrade in handling. Both density and solubility rates are easier to control.

You get greater production economies, too. The process is a simplified, continuous operation. It integrates smoothly into the rest of your system. It requires less auxiliary equipment, less power and lower capital investment than older, less efficient agglomeration methods.

Applications for this A-C compacting process are virtually unlimited. For complete information on what the process can do for you, contact your A-C representative or write **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wisconsin.* A-1388


Acetic Acid • Acetic Ether • Alcoho • Alum • Ammonia • Asphalt •
Banana Oil • Barium Sulphate • Brick Liquor •
• Boiler Feed Water • Borax • • Butadiene •
Butene • Butyl Acetate • Calciu Bisulfide
• Carbon Dioxide • Car halk •
Chlorine • Chloro onseed
Oil • Creos Diesel Fue • Alcohol •
Ethylen • Furfu • Glycerine
• Hyd • Kerosene • Kraft
Liquor Acetate • Methyl Alcohol
• Methy phtho • Nicotine • Nitric Acid •
Oleic Acid • Ole Pentane • Petroleum • Petroleum
Ether • Phenol • Phosphoric A Potassium Cyanide • Potassium
Hydroxide • Potassium Sulphide •
bonate • Sodium Bisulfite • Sodium Carbonate • Sodium Hydroxide • Sodium
Silicate • Sodium Sulfate • Sodium Sulfide • Sodium
Stearic Acid • Sulphuric Acid • Sulphur Dioxide • Tannic Ac
chloride • Tetrachlorethane • Toluol • Tri-Sodium Phosphate • Trichlorethylene • Turpentine •

ONE GASKET MATERIAL

that will handle over 120 different chemicals and their thousands of variations

DURABLA Homogeneous Compressed Asbestos Sheet Packing is a single-formula material that can be used with proved safety for the sealing of practically all oils, gases, alkalies, acids and hydrocarbons. It is suitable for a wide range of temperature-pressure combinations.

The versatility of this material results from the use of a greater percentage of selected Canadian asbestos fibre, of the spinning group, than is found in any other gasket material. The asbestos is skillfully compounded with a special binder. Every square inch of the sheet has uniform density, thickness and asbestos distribution.

DURABLA Sheet Packing is available in eight different gauges. Gaskets are supplied in all sizes and shapes, accurately machine cut.

Write for full information about *the* all-purpose gasket material. Ask for a copy of bulletin CE-11.

DURABLA MANUFACTURING COMPANY
114 Liberty Street, New York 6, N. Y.

DURABLA®

DM-37 *Manufacturers of DURABLA Pump Valves and Check Valves*

its way through a layer of liquid on every tray. This bubbling action, essential for vapor-liquid contact, requires energy, which is generated by heat input (and pressure) in the bottom of the column.

In the rotary tray unit, energy for the contact is provided by the rotor, which is driven by an external motor. Result: less heat input, lower temperature and pressure in the column bottom. Rotary-tray column is most effective in the pressure range of 1-20 mm. Hg absolute.—**Vulcan-Cincinnati, Inc., Cincinnati, Ohio.** 68D

Sealless pump

Magnetic drive eliminates need for rotating seal on shaft.

Magnedyne pump has no seals to leak corrosive fluids. Unlike so-called canned pumps, however, a standard motor drives the impeller. It's all done with magnets—one on the motor shaft, another on the impeller shaft—separated by a stainless steel diaphragm. Internal magnet, a special ceramic fused from barium titanate and ferric oxide, is noncorrosive.

Pump's wetted parts come in bronze, stainless steel, titanium and plastics—for various corrosive services. Internal bearings are either carbon, graphite or Teflon. Capacity range: 10-25 gpm. at 35-10 ft. head.—**Strand Co., N. Y., N. Y.** 148A

That ends the review. The rest of the items are new.

Thermal flowmeter

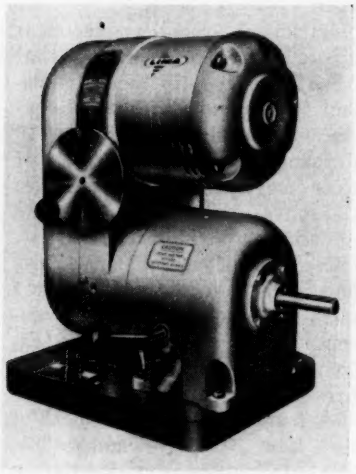
Obstructionless flowcell has smooth bore, no moving parts.

All sensing elements in a new thermal flowmeter are external, thus leaving a smooth, obstruction-

less path for the flowing stream. Instrument works best measuring flow rates in the laminar range, including Reynolds numbers up to 3-4,000. A single unit can cover a flow range of 1,000:1 for viscous liquids.

Two sections comprise the unit —a flowcell and an electronic indicator that generates a voltage output suitable for control of equipment or for driving recorders.

The stainless steel flowcell is particularly suited for measuring the flow of liquids that are: corrosive or radioactive, at high pressure, temperature, require sanitary handling. — **Flow Measurements Corp., Kensington, Md. 148B**



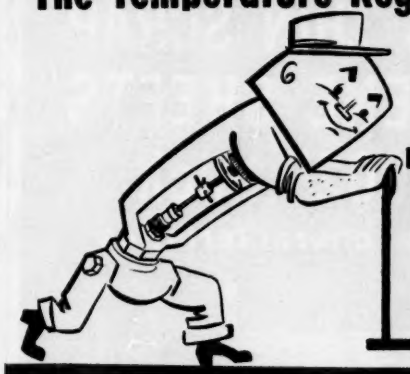
Variable speed drive

Control range is infinite from 1/10 to full motor rpm.

Called the Vari-Gear Drive, a new variable speed unit gives an infinite range of output shaft speeds from full motor rpm. down to $\frac{1}{10}$ of motor shaft speed. For instance, when used with an 1,800 rpm. motor, output speeds of 180 to 1,800 can be obtained.

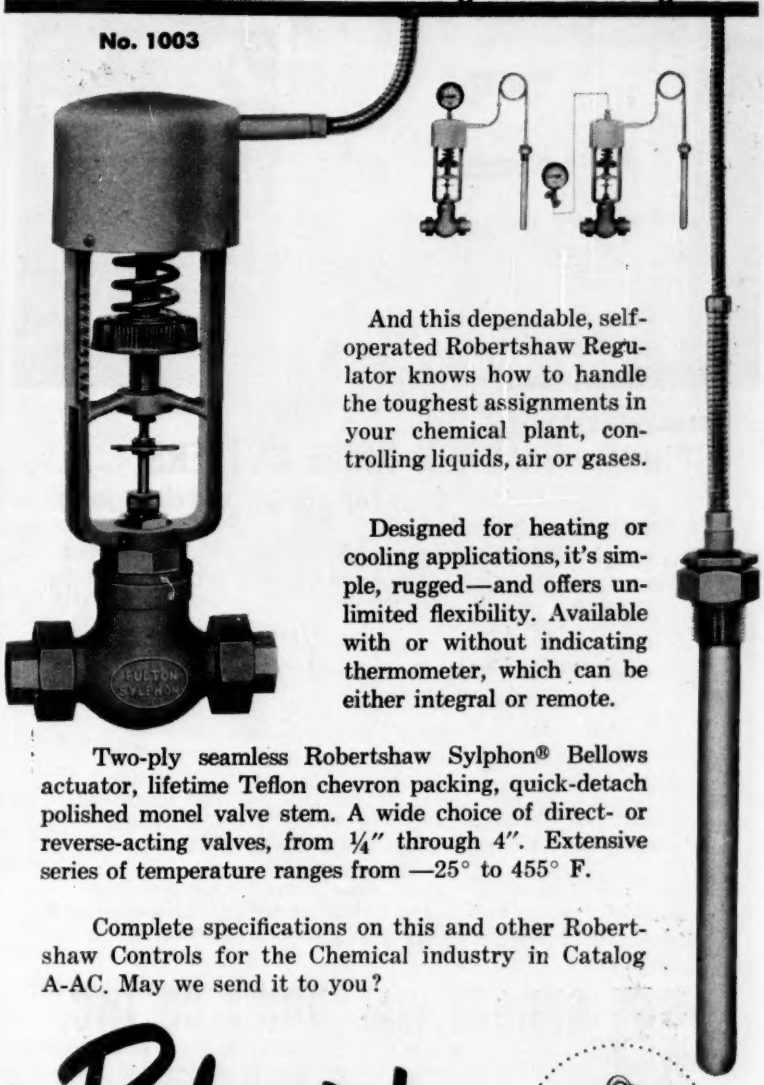
Desired rpm. is regulated with a simple control wheel, while the exact rpm. at which the output shaft is turning is shown on a calibrated speed plate. Incorporation of a four-speed transmission is said to result in three times greater torque at the low speed

The Temperature Regulator that



LIKES TOUGH JOBS!

No. 1003



And this dependable, self-operated Robertshaw Regulator knows how to handle the toughest assignments in your chemical plant, controlling liquids, air or gases.

Designed for heating or cooling applications, it's simple, rugged—and offers unlimited flexibility. Available with or without indicating thermometer, which can be either integral or remote.

Two-ply seamless Robertshaw Sylphon® Bellows actuator, lifetime Teflon chevron packing, quick-detach polished monel valve stem. A wide choice of direct- or reverse-acting valves, from ¼" through 4". Extensive series of temperature ranges from —25° to 455° F.

Complete specifications on this and other Robertshaw Controls for the Chemical industry in Catalog A-AC. May we send it to you?

Robertshaw

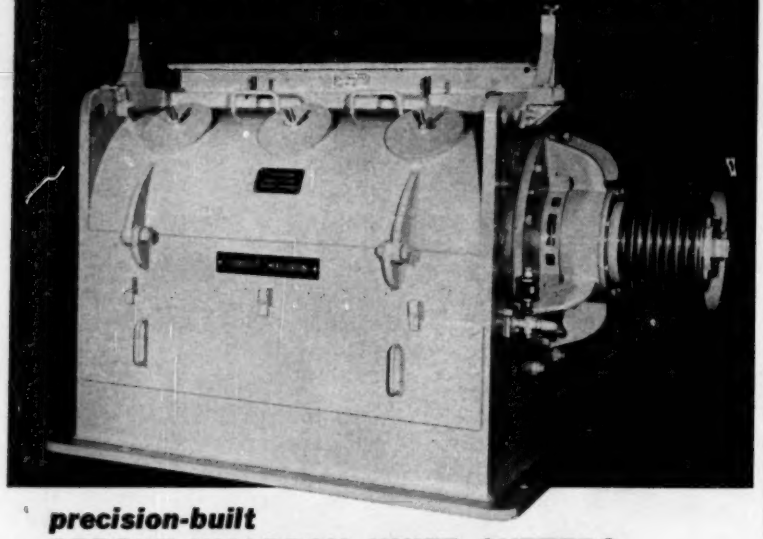
MR. CONTROLS

Robertshaw-Fulton Controls Co.

FULTON SYLPHON DIVISION, KNOXVILLE 1, TENNESSEE

GRANULATES THIN SCRAP POLYETHYLENE SHEETS .001" to .002" thick

with better flow characteristics



precision-built

SPROUT-WALDRON KNIFE CUTTERS

for tough cutting jobs

It's true, no two jobs of size reduction are the same, but Sprout-Waldron precision engineered knife cutters are doing a lot of tough size reduction jobs with superior results. Their application and versatility are practically unlimited.

Such tough cutting jobs as these—*and others*—are being handled efficiently on Sprout-Waldron cutters . . .

Rubber reduction; cutting thin plastic film sheets continuously; flocking alpha pulp; pre-cutting and flocking rags, fabrics, leather and other fibrous materials; granulating thermoplastics, chalk and charcoal; and processing tobacco leaves, stems, vegetables, roots, shavings, bark, foil, chemicals, drugs and other materials.

Check with Sprout-Waldron on your size reduction problems . . . our modern testing facilities and years of design, engineering and manufacturing experience are available to assist you. *Write for Bulletin 213.*

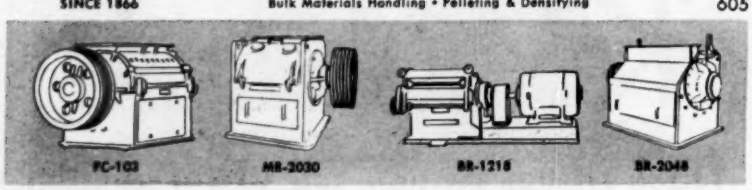
SW SINCE 1866

SPROUT, WALDRON & CO., INC.

MUNCY, PENNSYLVANIA

Size Reduction • Size Classification • Mixing & Blending
Bulk Materials Handling • Pelleting & Densifying

605



than in any comparable friction-type unit.

Either dripproof or totally enclosed units are available in ½, ¾ or 1 hp.—**The Lima Electric Motor Co., Lima, Ohio.** **149A**

Miniature recorder

Small as a conventional meter, it accepts electrical signals.

Any variable that can be converted to an electrical signal can be recorded by a new miniature circular-chart recorder as small as a conventional meter. Smaller than a 4-in. cube, it requires no pen, ink or ribbon, prints by means of a stylus on pressure-sensitive paper.

Instrument records electrical voltage, current or power—signal is fed directly into meter movement without need for amplification even for signals as low as 10 microamperes. Four types of meter movements are available: D'Arsonval, cross coil, moving iron and ferrodynamic.

Small size of instrument permits nine of them to be mounted in 1 sq. ft. of panel area. One instrument fits in an inexpensive explosionproof housing. A built-in three-position sliding lever provides a three-speed adjustment of the 3-in. chart.—**Thomas A. Edison Industries, McGraw-Edison Co., W. Orange, N. J.** **150A**

No-spill bucket

Tractor-shovel accessory helps to keep work areas clean.

A new no-spill bucket device on rubber-tired tractor shovels helps to reduce spillage of bulk materials during handling within a plant, saves expense of cleanup and reprocessing of spilled materials.

The sides of new buckets are curved to conform to the arc traveled by a combination striker-

How Plant Engineering Teamwork Increased Polyethylene Capacity 1200% In 5 Years

In less than 5 years, U.S. Industrial Chemicals Company has increased its capacity for polyethylene from 25 million pounds to 300 million pounds—to become the world's second largest producer of this popular plastic material.

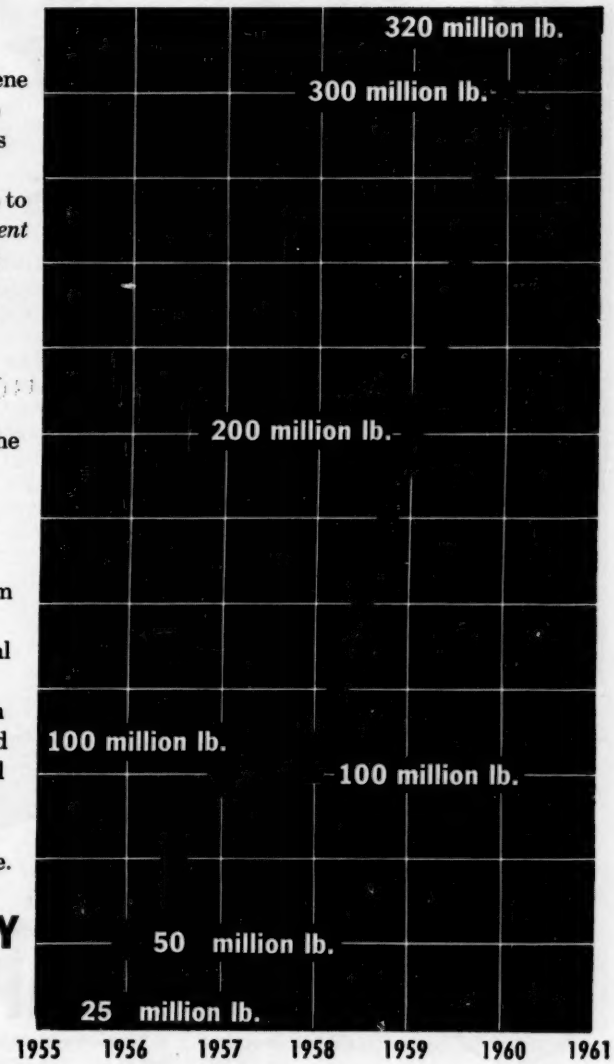
Engineering and building all the various facilities to attain this position so rapidly, *with optimum investment for each project*, is a story of continuing teamwork between U.S.I. and The M. W. Kellogg Company.

It started in 1955, when Kellogg was given the over-all responsibility for U.S.I.'s first PETROTHENE® polyethylene plant, a 25-million-pound grass roots project in Tuscola, Illinois.

In 1956, Kellogg was commissioned to double the capacity of the Tuscola plant—and to double it again in 1957.

In 1959, the same close teamwork put a brand new 75-million-pound PETROTHENE plant on stream in Houston, Texas. This was increased from 75 to 100 million late in 1959. And in 1960, it doubled *this* plant's output—bringing U.S.I.'s total capacity to 300 million pounds.

If you are planning new or expanded production facilities at home or abroad, Kellogg would be glad to show you how teamwork—which coordinates all engineering, procurement, and construction steps under one integrated international management—could work to *your* company's economic advantage.



THE M. W. KELLOGG COMPANY

711 Third Avenue, New York 17, N. Y.

A subsidiary of Pullman Incorporated

Offices of Kellogg subsidiary companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires

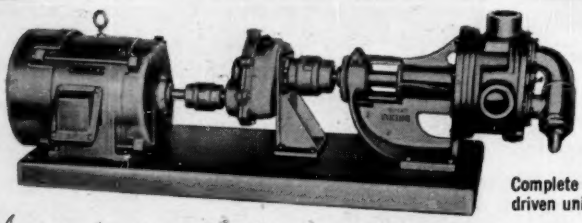
STEP UP SPEED AND CAPACITY-REDUCE COSTS AND OPERATING EXPENSE

Unmounted Pumps
½ to 300 G.P.M.
Pressures up to 100 P.S.I. Lubricating liquids.
50 P.S.I.—Non-Lubricating liquids

WITH NEW VIKING ALLOY PUMPS

You can operate Viking's complete NEW line of Heavy-duty Stainless Steel and other alloy pumps at 100% rated speed on thin liquids. Others in the line have also been stepped up in speed and capacity. You can have greater capacity at lower cost by using a smaller size Viking pump. Save up to $400 on some applications. You can also reduce horsepower requirements and cut down on operating expense with higher speeds. Viking's new electric alloy castings and latest manufacturing processes give you a still better pump. Mechanical seals, integral relief valves, revolvable castings are standard. O-ring gaskets if desired.

Stainless Steel, Monel, Nickel, Steel, Nodular Iron, Ni-Resist, and others.



Complete Motor-driven units

For full information, send for catalog MC

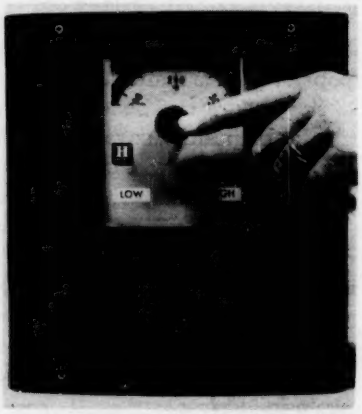
50 YEARS

VIKING PUMP CO.

Cedar Falls, Iowa, U.S.A. • In Canada, It's "ROTO-KING" Pumps
See Our Unit In Chemical Engineering Catalog

bar-spillguard. This device, moved hydraulically from the top side of the back of the bucket to the front, strikes off excess material that has been scooped from a pile. Bar remains at the front as bucket is lifted to carry position, serves as a front spillguard and load retainer during travel.

At the end of the travel cycle, device is retracted so load can be dumped in normal fashion. The hydraulic system is designed so bucket and strikerbar operations can be handled separately. No-spill device is available on manufacturers 2,000, 2,500 and 3,000-lb. capacity tractor-shovels. — **The Frank G. Hough Co., Libertyville, Ill.** **150B**



Temperature controller

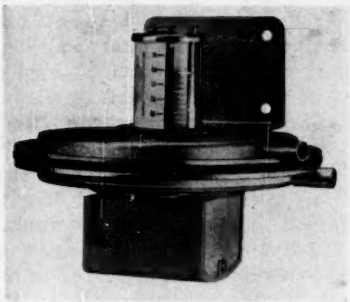
Electronic unit holds preset temperature within ±4 deg.

Designed for a wide variety of temperature control operations, a new thermocouple-operated potentiometer operates at temperatures from −200 to +2,000 F., controlling to within ±4 deg.

Heart of the system is a transistorized amplifier-relay panel containing all necessary operating controls and circuitry. Temperatures are sensed with almost any type of thermocouple; accurate control is possible with resistances of as much as 20 ohms in the lead wire between the couple and unit.

Nonindicating, the controller contains a built-in time propor-

tioning unit that prevents temperature overshoot, according to the manufacturer. Adjustments are made by turning a dial on the panel. Three lights indicate if the power is on and whether temperatures are above or below the set point. — **Minneapolis-Honeywell Regulator Co., Minneapolis. 152A**



Pressure switch

Differential-pressure unit works in very low ranges.

A pressure increase of only 0.05 in. of water will actuate a new pressure switch to open a circuit; switch will close circuit on a decrease of 0.03 in. Repetitive accuracy is said to be within 1% with no error due to drift or hysteresis.

Marked in in. of water, the unit's pressure set point is visible on an accurate scale. Calibration adjustments may be sealed or safety wired to make the switch tamperproof. Explosion or weatherproof housings, special low-temperature diaphragm, or fail-safe pilot lights are optional.

Switch is suitable for liquid level control, induced draft interlocks, exhaust hoods, dust collection systems and air filters.—**F. W. Dwyer Mfg. Co., Michigan City, Ind. 153A**

Dust collector

Modular-type unit automatically sets cleaning, operating cycles.

Set it up, turn it on—and a new

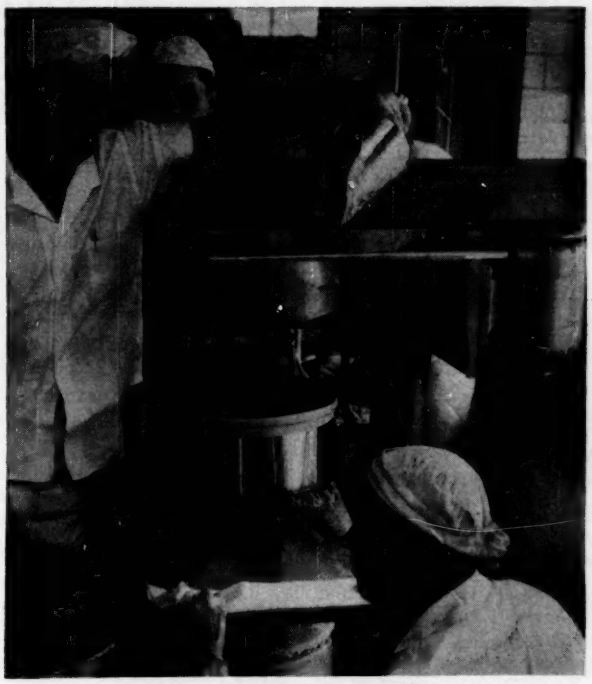
at Bristol Laboratories...

STOKES TORNADO MILLS CUT 30% FROM NALDECON DRYING TIME

Naldecon, a long acting nasal decongestant, is being manufactured faster thanks to a new process in which Stokes Tornado Mills figure prominently. With the Stokes Mills, Bristol realizes a 30% savings in drying time. With its large 360° screening area, the Tornado Mill can handle wet material quickly and easily. In addition to speeding drying, the Mills provide more even granulations of the material than the equipment formerly used.

The versatile Stokes Mills are used for both dry and wet granulations. Wet agglomerates are reduced to a uniform size before drying. Bristol reports they get better drying, improved product quality, greater product uniformity, and fewer fines.

Find out how the Tornado Mill can increase the efficiency of your operations. Stokes Advisory Service will run tests on a sample of your material . . . at no obligation. Call or write . . . today.

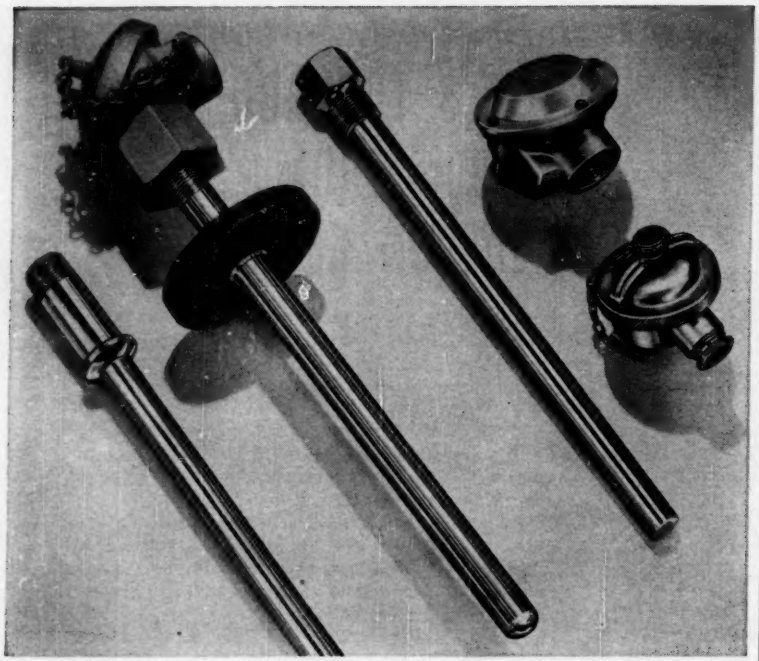


Operator loads one of three Stokes Tornado Mills which is used in the manufacture of Naldecon at Bristol Laboratories in Syracuse, N.Y.

Size Reduction Equipment Division

STOKES

F. J. STOKES CORPORATION
5500 TABOR ROAD, PHILADELPHIA 20, PENNSYLVANIA



Thermocouple Assemblies For Every Industrial Use

Thermo Electric's base metal thermocouple assemblies give consistently reliable temperature readings for ranges between —300°F. and +2200°F. We specialize in solving problems caused by chemical attack, pressure and installation difficulties . . . and offer the most complete variety of standard thermocouple assemblies in the industry. See our new 16 page catalog for the many types available.

Thermocouples

Single and multiple junction thermocouples are made of all standard thermocouple materials and gage sizes. Ceramic insulated, metal sheathed "Ceramo-Couples" are used most effectively for extended life at high temperatures or for sub-zero conditions where condensation is a problem. These temperature sensing elements have excellent resistance to moisture, petroleum products, chemical action and abrasion, and are often used without additional protection tubes. The wires used in all these thermocouples are drawn, annealed, insulated and calibrated in our own wire mill under Thermo Electric's high standards for mechanical and thermoelectric qualities.

Thermowells

The selection of over 5700 standard Thermowells includes bar stock or built-up construction, test wells and extra sensitive wells; and a variety of mounting fittings and flanges. Many construction materials available—all wells are pressure tested.

Connection Heads

Choose from six different types, including heavy duty cast iron heads, lightweight aluminum heads, and quick-opening heads. All weather proof—many sizes.

Write For New Catalog E-4

Our Thermocouple Catalog has complete information, simplified ordering instructions for all assemblies and components, and a Thermowell Material Guide for hundreds of industrial applications.

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

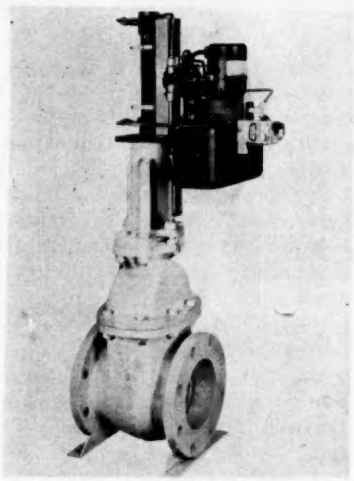
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

dust collector will automatically filter gas and clean itself on a regular cycle. From 2 to 12 modules may be combined to make up a total unit, depending on the dust load to be handled.

Collected dust is removed from the filter area periodically. On a regular cycle, the cloth filter tubes are shaken while air is blown through them in reverse. The dust falls into an adjustable screw conveyor in the base, which moves all the dust to a point where it is discharged through a rotary valve.

A single ¾-hp. motor supplies power for the collector. A blower is installed on the clean-air side of the collector to keep the unit under suction at all times. Each section has its own quick-opening door to provide quick access to internals.

A 12-section model can handle up to 58,000 cfm. air, according to the manufacturer. Cotton sateen cloth is standard on the filters although other materials are available for special applications. Aluminum construction lightens floor load.—**Torit Mfg. Co., St. Paul.** 153B



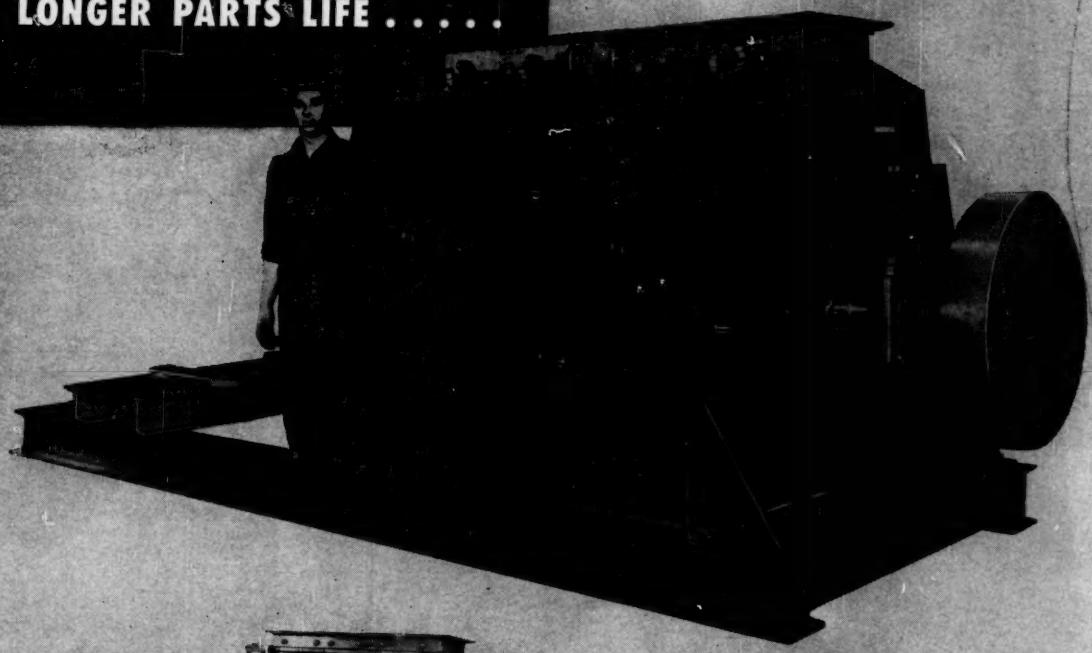
Valve actuator

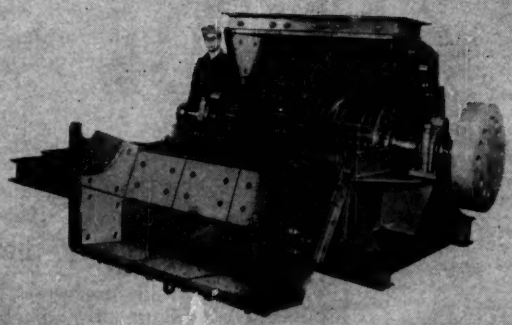
Hydraulic unit locks to hold setting in desired position.

Suitable for use on virtually any type or size of valve, a new hydraulic valve actuator provides an automatic locking feature that

NEW DUAL "2-POINT" ADJUSTMENT INSURES MORE UNIFORM GRINDING, LONGER PARTS LIFE . . . . .

WILLIAMS *Reversible* HAMMER MILLS





Williams Reversible Hammer Mill with cover open. Note these features:

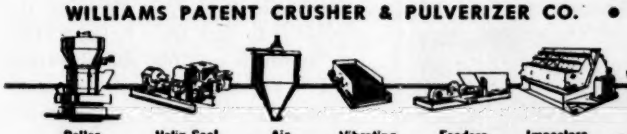
- Super-strong reinforced steel plate frame
- Renewable wear-resistant manganese steel liners
- Heavy duty oversize forged steel rotor shaft
- Anti-friction self-aligning roller bearings in dust-tight housings
- Complete accessibility to interior for quick parts changing

It's another Williams "first"—features not available in other hammer mills—that now makes it possible to maintain the original close clearances of *both* grinding plates *AND* cage sections against the rotating hammers. This easy-to-make "2-point" adjustment, in the most critical grinding area inside the hammer mill, gives absolute assurance of consistently uniform product quality.

In addition to the advantages of the Dual "2-Point" Adjustment, a Williams Reversible Hammer Mill substantially lowers upkeep expense by cutting hammer cost. Hammers can be operated in one direction today and another tomorrow simply by installing a simple reversing switch on the driving motor. Manual reversing of hammers no longer necessary. Grate bars also last longer. The double set of reversible manganese breaker plates, which last twice as long as other types, give four times the service! Maintenance and downtime are cut 50% or more.

Get all the facts about the hammer mill with *ALL* the top features.

WILLIAMS PATENT CRUSHER & PULVERIZER CO. • 2706 N. Ninth St. • St. Louis 6, Mo.

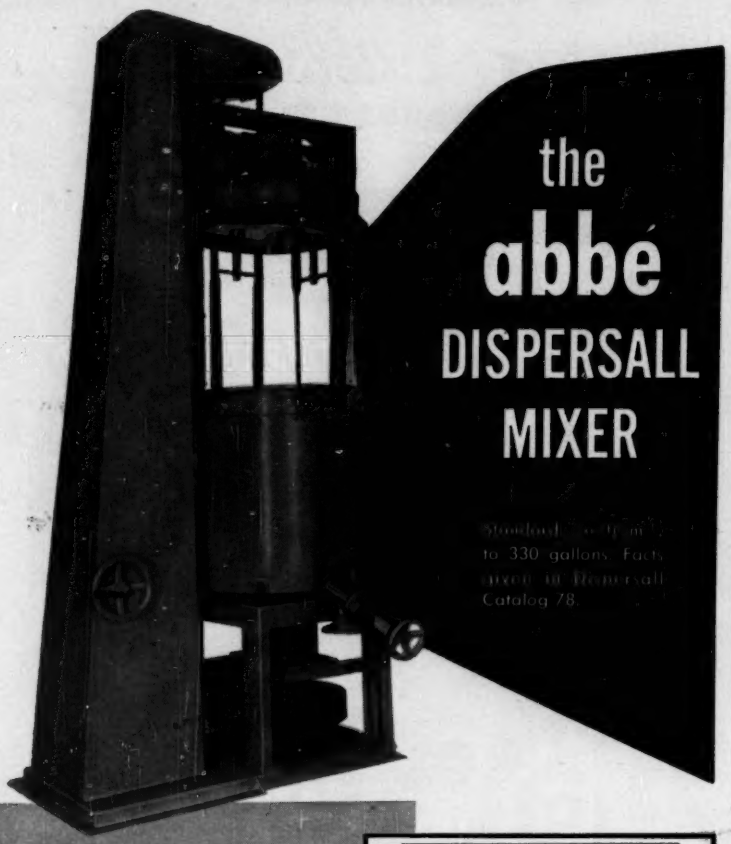


WILLIAMS

CRUSHERS GRINDERS SHREDDERS

Oldest and Largest Manufacturers of Hammer Mills in the World

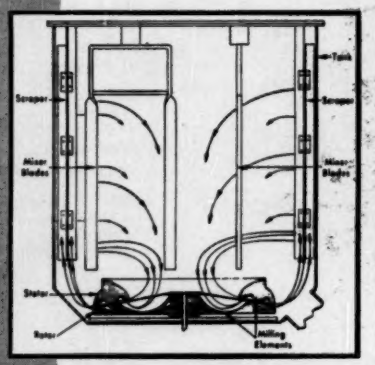
LIQUIDS, SLURRIES, PASTES



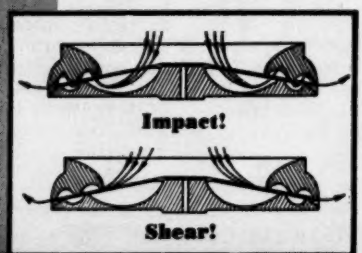
the abbé DISPERSALL MIXER

Standard [illegible] to 330 gallons. Facts given in Dispersall Catalog 78

FAST, THOROUGH, COMPLETE ACTION!



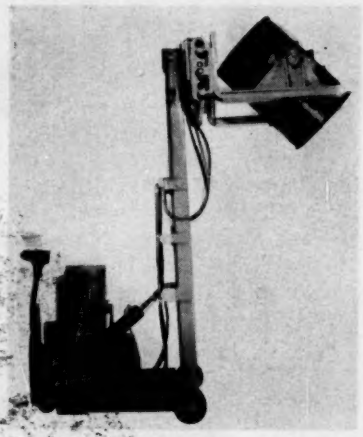
... BLENDS
DISPERSES
EMULSIFIES
DISSOLVES
MIXES



abbé ENGINEERING COMPANY
620 F Graybar Bldg., New York 17, N. Y.
Designers and Manufacturers of
Ball, Pebble and Jar Mills · Pulverizers · Sifters · Cutters · Mixers

holds the gate or plug in any desired position almost indefinitely. Motor and pump run only for the few seconds required to open or close the valve.

Miniaturization of components and elimination of external valving enable the unit to fit within over-all valve dimensions on most applications. Actuator can be set up for direct or remote control, and can be equipped with a hand pump for use in event of power failure or on applications where power supply is not available or may not be required due to infrequent valve operation.—**Oil-Dyne, Inc., Chicago.** **154A**



Drum stacker, tipper

Electric fork-lift push-truck stacks and up-ends barrels.

Counterbalanced for increased safety, this new light-weight electrical truck can not only high-stack wooden and steel barrels in the conventional fork-lift manner, but also up-ends them for 180° forward dumping.

Key to the up-ending operation is a clamp that is adjustable for different barrel diameters. In combination with a 180° forward-rotating cylinder, it permits the operator to pick up a drum weighing as much as 1,500 lb., elevate it to 106 in., and dump it—all without leaving his place at the truck's control handle.

When the clamp and up-ender

units are detached, the corrosion-resistant truck can be used for conventional skid and pallet handling. — **Lewis Shepard Productions, Watertown, Mass.** 156A

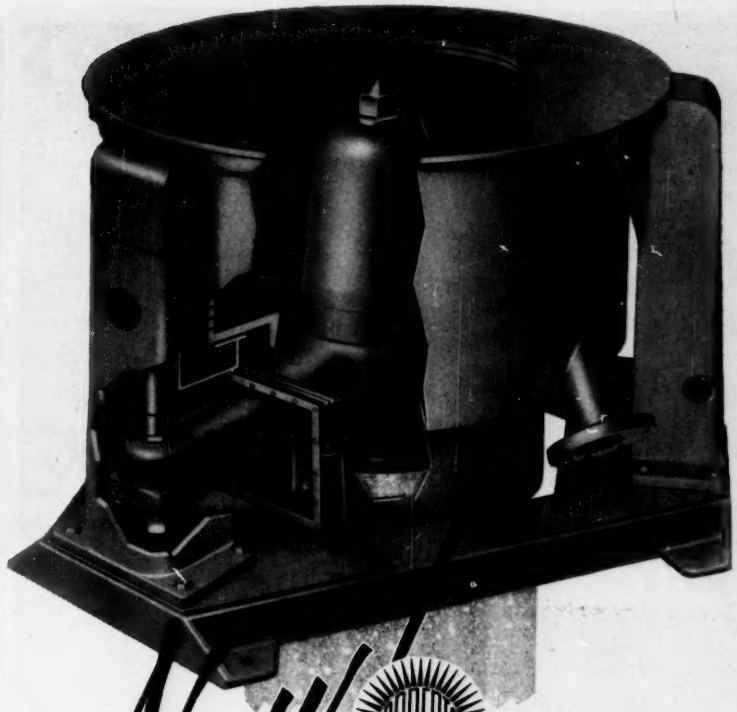
Barrel warmer

Tilting, rolling cradle keeps drums of viscous liquid warm.

Designed for small batch operations requiring frequent draw-off, this drum cradle features an electrical heating unit that maintains drums of viscous liquids both warm and of the desired consistency.

The cradle, when tilted almost vertically, can be rolled from place to place like a hand pick-up cart. Tip it down to a horizontal position, plug it into the nearest wall socket, and it becomes a warming stand for a standard 55-gal. drum. Even such highly viscous liquids as paint, grease, resin, heavy oil, shortening, and the like will spigot-drain by gravity from this position, thus eliminating the need for a pump.

Models of the semi-cylindrical, asbestos-gasketed heating unit are made for two thermostatically-controlled temperature ranges (60 -250 F. and 100-450 F.) and four wiring systems (115, 208, 230 and 460 v., single or three-phase). Other features include a center drain to prevent accumulation of spillage, plus an optional flame-



Now! the ROBERTS LS/SC

a Link Suspended, Stationary Curb centrifugal machine which provides a combination of features long wanted by the Chemical Process Industries.

Features . . . Link Suspension! No metal to metal moving parts. No lubrication. Soft lateral movement. No vertical movement. Effective damping. This suspension isolates dynamic parts from curb and foundation and reduces vibration to an astonishing low.

Features . . . Stationary Curb! With rigid feed, wash, effluent, and solids-discharge connections. No vibration damage to curb mounted accessories. Extends bearing life by reducing bearing loads. Increases personnel safety. Provides rapid drainage, more effluent capacity.

Features . . . Direct Coupled Hydraulic Motor! No belts. Compact. Light weight. Provides power for exclusive, slow speed, reverse discharging. Provides adjustable loading speed and adjustable top speed. Hydraulic braking (even at power failure). No brake linings to wear. Constant horsepower drive reduces peak electric loads.

Features . . . Oversize Anti-friction Bearings! Basket spindle bearing housing is air purged. This feature, designed to protect bearings from damaging effects of process material environment, also provides a convenient means for introducing controlled atmosphere within the basket. Can be grease lubricated while in operation. No-belt design — no belt-pull-loading on the bearings.

2905

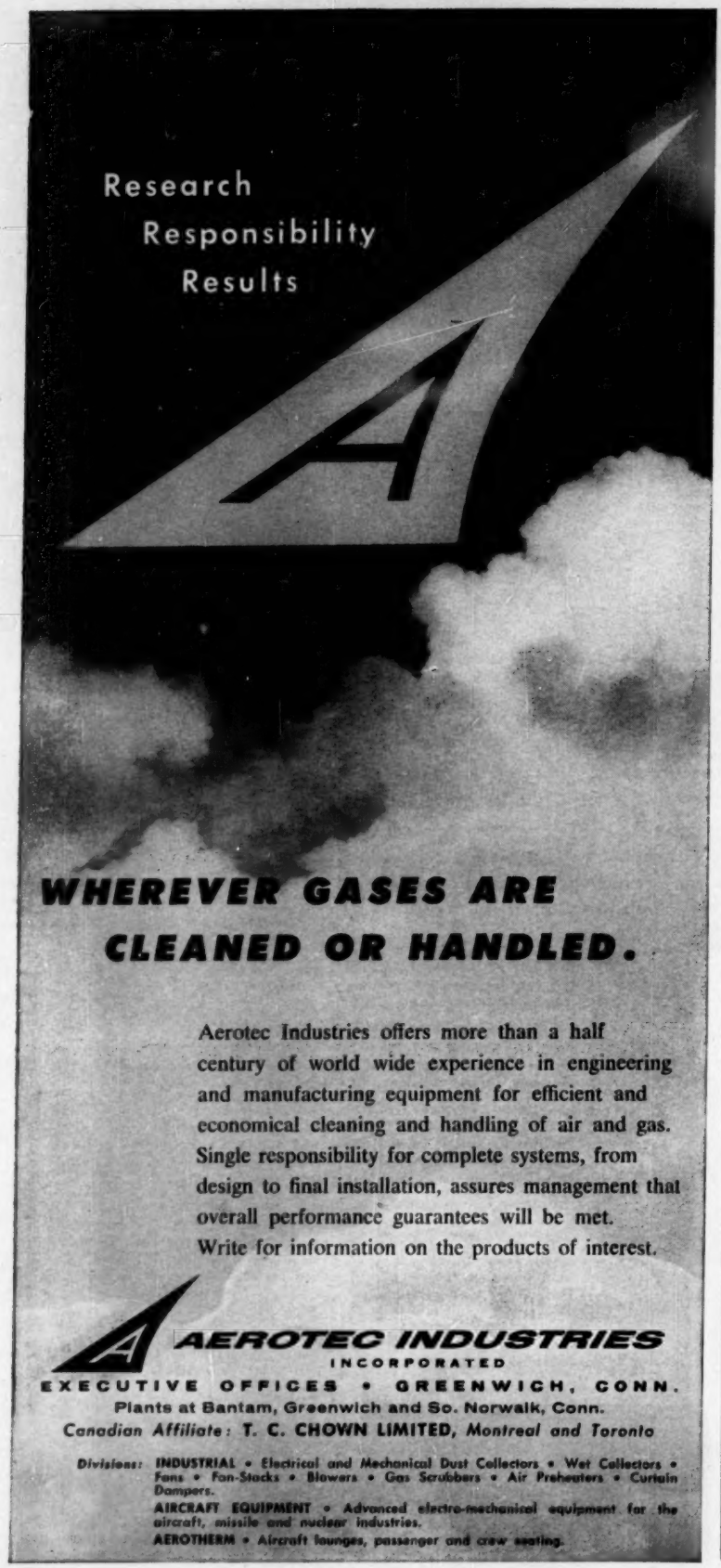
Investigate its potential in relation to your operation. We will welcome the opportunity to co-operate with you.

ROBERTS STEVENS

The WESTERN STATES MACHINE COMPANY

1700 Fairgrove Avenue

HAMILTON, OHIO, U.S.A.


Research
Responsibility
Results
WHEREVER GASES ARE
CLEANED OR HANDLED.
Aerotec Industries offers more than a half century of world wide experience in engineering and manufacturing equipment for efficient and economical cleaning and handling of air and gas. Single responsibility for complete systems, from design to final installation, assures management that overall performance guarantees will be met. Write for information on the products of interest.
AEROTEC INDUSTRIES
INCORPORATED
EXECUTIVE OFFICES • GREENWICH, CONN.
Plants at Bantam, Greenwich and So. Norwalk, Conn.
Canadian Affiliate: T. C. CHOWN LIMITED, Montreal and Toronto
Divisions: INDUSTRIAL • Electrical and Mechanical Dust Collectors • Wet Collectors • Fans • Fan-Stacks • Blowers • Gas Scrubbers • Air Preheaters • Curtain Dampers.
AIRCRAFT EQUIPMENT • Advanced electro-mechanical equipment for the aircraft, missile and nuclear industries.
AEROTHERM • Aircraft lounges, passenger and crew seating.

proofed canvas cover. A web belt fastens drums securely in place.—**Harold L. Palmer Co., Farmington, Mich.** **157A**

Briefs

Pump coupling-guard of reinforced polyester resin weighs ⅓ as much as steel, has color blended in the resin. Available in four standard sizes or made to order, unit is corrosion resistant and durable. Also available as a belt guard.—**Armadillo Plastics Co., Houston.** **158A**

Emulsifier uses forces of impact, attrition, turbulence and ultrasonic cavitation to disperse, stabilize, emulsify or blend liquids or liquid-solid mixtures. Three-stage process with continuous recycling is said to reduce particles to their minutest dimensions. Rotor-stator clearance can be adjusted.—**Buschman Products Inc., New York.** **158B**

Aersol first-aid spray is instantly available to treat burns. Available in 8-oz. can, it coats the skin, provides pain relief, reduces swelling, guards against secondary infection, and forms an invisible film that isolates the burn, eliminates the need for bandages.—**Scientific Equipment Co., Philadelphia.** **158C**

Aluminum container, for shipping and in-plant handling of liquids, pastes or granular materials, consists of two cylindrical sections joined by a peripheral clamp. When empty, it comes apart so the units can be nested inside each other to reduce return shipping space. It is available in liquid and granular models.—**Kaiser Aircraft & Electronics, Div. Kaiser Industries Corp., Oakland, Calif.** **158D**

Rotary diverter valve, heavy duty and air operated, provides a positive no-dribble shutoff when diverting powders or granular products from one line to another. Available in cast iron or stainless steel, units may be operated re-

motely.—**Sprout, Waldron & Co., Inc., Muncy, Pa.** **158E**

Chart changer for circular chart recorders makes it possible for a recorder to operate unattended for up to 16 days, using a new 24-hr. chart each day. A chart plate holds the charts and a chart scroll moves the used charts out of the way without interrupting the sequence.—**Barton Instrument Corp., Monterey Park, Calif.** **159A**

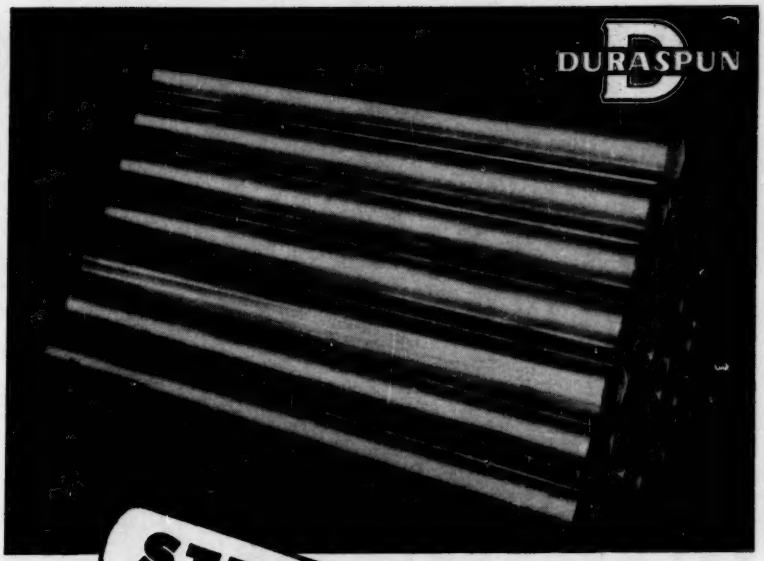
Gear reducer, shaft mounted, has ratios from 3½:1 to 36:1 in range from 4 to 30 hp. It is available with either steel or aluminum housing. — **Crichton Co., Johnstown, Pa.** **159B**

Vacuum pump for general purpose high-vacuum applications is rated at 140 l./min. at atm. pressure, will pump down to 10 microns Hg. It is recommended by the manufacturer as a backing pump for oil or mercury diffusion pumps or as a roughing pump in a complete vacuum system.—**Central Scientific Co., Chicago** **159C**

Equipment Cost Indexes . . .

	June 1960	Sept. 1960
Industry		
Avg. of all	238.2	237.4
Process Industries		
Cement mfg.	232.8	231.7
Clay products	226.2	225.6
Glass mfg.	226.6	225.3
Paint mfg.	229.8	229.1
Paper mfg.	231.3	229.9
Petroleum ind.	234.1	234.0
Rubber ind.	237.6	236.9
Process ind. avg.	236.5	236.2
Related Industries		
Elec. Power equip.	242.7	240.2
Mining, milling	241.5	240.0
Refrigerating	268.5	267.7
Steam power	225.0	224.3

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124–6 for method of obtaining index numbers; April 4, 1960, pp. 149-50 for annual averages since 1913.



STRONG is the word for Centrifugally Cast Pipe

. . . and the alloying is selected so that you will get high resistance to corrosion or high resistance to extreme heat or high resistance to both, as you require.

Centrifugally Cast Pipe has been a major DURALOY item since 1933 when we pioneered such high alloy castings in this country. Standard pipe production is in the following classification:

Outside Diameter	Minimum Wall	Length
2½" to 3"	1/4"	88" maximum
3" to 6" Inclusive	5/16"	110" maximum
Over 6" to 12" Inclusive	3/8"	168" maximum, 24" minimum
Over 12" to 14" Inclusive	7/16"	168" maximum, 24" minimum
Over 14" to 20" Inclusive	1/2"	180" maximum, 48" minimum
Over 20" to 24" Inclusive	1/2"	88" maximum
Over 24" to 32" Inclusive	5/8"	80" maximum

ALLOY CASTING INSTITUTE ACI MEMBER

RESISTANT is the word for Chrome-Nickel Alloying

The strength of Centrifugally Cast Pipe comes largely from the exceptionally uniform dense grain structure.

If you require a gas or liquid pipe line or a process tube requirement calling for high strength plus high resistance to corrosion and/or temperatures in the piping, DURALOY Centrifugally Cast Pipe will meet your specifications with complete satisfaction. This is the record of our castings in industry for many, many years.

The DURALOY Company

OFFICE AND PLANT: Scottdale, Pa.

EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.

CHICAGO OFFICE: 332 South Michigan Avenue

DETROIT OFFICE: 23908 Woodward Avenue, Pleasant Ridge, Mich.

ALL WEAVES
ALL METALS
ALL WEIGHTS

In rolls or cut to size

Be certain you are using the BEST, MOST EFFICIENT woven wire filter cloth for your processing. We at NEWARK know filtering and we know from experience and testing, the best wire and the best weave for a given process.

Space Cloth
Filter Cloth
Bolting Coth
Mesh Cloth
Backing Cloth
Sieves
Strainers
Centrifugal Cloth

Fabricated Wire Cloth Parts

NEWARK for ACCURACY

Send for a copy of Bulletin F-C.

Newark Wire Cloth COMPANY

351 Verona Avenue • Newark 4, New Jersey

Technical Bookshelf

THE FLAMES OF CONTROVERSY

THE CRISIS WE FACE—Automation and the Cold War. By George Steele and Paul Kircher. McGraw-Hill Book Co., New York. 220 pages. $4.95.

There's practically nothing better on a cold winter's night than to curl up before a roaring fire with a truly controversial book. Such a book is now making the rounds (and maybe the fireplaces, depending on your viewpoint).

The authors of "The Crisis We Face" are in a mood for controversy. They feel an economic/military crisis is imminent. And they assume that the worst may happen—"As we think it is the responsibility of the military [to so assume]"—as they present a full-blown picture of our offensive and defensive systems, complete with weaknesses, past, present and potential.

They haven't impressed everyone, however. Sharp rebuttal comes from Major William L. Still of the Air Force in the December issue of *Control Engineering*. He disagrees with a lot of what Steele and Kircher have to say, particularly as regards his own province, the Minuteman project (he is Chief, Ground Equipment Branch, Minuteman Program Office).

In an opening salvo, Still sets off no mean Roman Candle of his own. After quoting three separate paragraphs from the text, he exclaims, "These are a few examples of irrational and irresponsible statements made within The Crisis We Face. . . ." He then proceeds to take potshots at many points, meanwhile giving a rundown of Minuteman doings.

This is an important controversy, meriting attention. And the issues are clearly drawn. Steele and Kircher (the former is a private computer consultant; the latter, an associate professor in the School of Business Administration at UCLA) are certainly very interesting, and so is Still. You might enjoy getting copies of both book and magazine, and then reaching your own conclusions.—HSG

In Rapid Review

Energy in the American Economy, 1850-1975. By S. H. Schurr, B. C. Netschert, et al. Johns Hopkins Press, Baltimore. 774 pages. $12.50. Energy's role in the U. S. economy, past and future, gets its full measure of exploration in this massive new study by staff members at Resources for the Future, Inc. Part I analyzes the fast-moving century just past, in which fuel dominance shifted from wood to coal to oil and gas. Future demand, Part II, is deduced from a detailed analysis of consumption within categories such as households, transportation and industry. Voluminous tabular material supplements the section. Estimates of future energy supply, Part III, are presented against the background of a comprehensive survey of all recent estimates of the reserves and resources of the specific energy sources—coal, oil, gas and hydropower.

Quantum Theory of Atomic Structure. Vol. I. By J. C. Slater. McGraw-Hill Book Co., New York. 502 pages. $11. This is an extension and expansion of Dr. Slater's earlier text, "The Quantum Theory of Matter" (1951). The present volume is aimed to be an introductory one, designed for first-year graduate study. The second volume is planned as a more advanced reference text. Treatment is straightforward but just as the subject matter is not an easy one, the book is written in a rigorous and demanding way.

Molecular Structure—The Physical Approach. By J. C. D. Brand and J. C. Speakman. St. Martin's Press, London. 300 pages. $8. The approach to molecular structure problems is one of the physicist, with emphasis on geometrical and topological facets. Treatment includes chapters on symmetry, wave mechanics, rotation and vibration, nuclear magnetic resonance, Raman, X-ray and electron diffraction. The absence of electronic spectra, deliberately not included by the authors, leaves much to be desired from the chemist's viewpoint.

Technique of Organic Chemistry. Vol. I. Physical Methods of Organic Chemistry. 3rd completely revised and augmented ed., part II. Ed. by A. Weissberger. Interscience Publishers, New York. 902 pages. $24.50. Topics comprising diffusivity, ultracentrifugation, refractometry, crystallographic analysis, microscopy and spectroscopy with light, X rays, electrons and neutrons have been brought up-to-date. While the main title is still Technique of Organic Chemistry, contained therein is a considerable amount of intesting yet nongermane subject matter that could be culled with advantages to space, price and purpose.

Nicholson Thermostatic Steam Traps

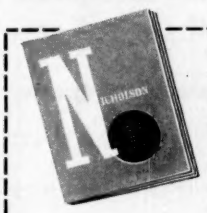
These traps are only a fraction of your steam equipment cost . . . yet they can do a whale of a job in helping you to get full efficiency from that equipment even with varying pressures. Here's how.

Operating on a true balanced vapor-pressure principle, they discharge air, condensates and other non-condensables promptly, fully and intermittently. What's more, the bellows is located where it belongs . . . at the trap top . . . so that when live steam enters it contacts the bellows the moment the discharging condensate falls below the top of the inlet pipe. Thus, there is a constant water seal to prevent loss of live steam. This, plus the fact that valves and seats are accurately lapped for sure, safe shut off assures you of full thermal efficiency from every pound of steam. Capacity? These traps have it . . . up to six times greater than ordinary traps. Also since there's only one moving part . . . no links, pin, levers . . . your maintenance cost is next to nothing.

Get maximum Thermal efficiency from your equipment. Specify Nicholson Thermostatic Steam Traps. Immediate delivery.

W. H. NICHOLSON and COMPANY
12 Oregon St., Wilkes-Barre, Pa.
Offices in principal cities

Send for Catalog



W. H. NICHOLSON and COMPANY
12 Oregon St., Wilkes-Barre, Pa.
Please send a copy of Catalog #400
NAME _____
COMPANY _____
STREET _____
CITY _____ **STATE** _____

BAUXITE · CLAY · PLASTICS · TALC · WOODFLOUR · LIME
LIME · MALT · RESINS · SALT · STARCHES · DETERGENT POWDERS · FEEDS · PLA
FLOUR · CATALYSTS · SUGAR · CAT

if it can be air conveyed
FLO-TRONICS®
fluidization can do it

. . . more economically and efficiently! Since their introduction, more and more firms using powdered or granular materials are realizing tremendous savings with Flo-Tronics Fluidization air conveyance systems. They eliminate the cost of individual containers, vastly reduce costs of hand labor, free space and working capital, and provide complete sanitation.

Typical savings (on an investment of $24,000) realized by a paper mill handling bulk starch are illustrated in this table.

	2,000,000 lbs.	3,000,000 lbs.
Volume (one type of starch)		
Annual Savings		
(a) *Bulk Price Differential—$.27/cwt*	$5,400	$8,100
(b) *Unloading, handling & losses—$.15/cwt*	3,000	4,500
TOTAL SAVINGS	$8,400	$12,600
Annual Costs		
(a) *Depreciation (over 15 years)*	$1,600	$1,600
(b) *Taxes (1% of investment)*	240	240
(c) *Repairs & maintenance (4%)*	960	960
(d) *Operation (labor, power, etc.)*	380	550
TOTAL COSTS	$3,180	$3,350
Summary		
Annual savings before Federal Inc. Taxes	$5,220	$9,250
Return before Federal Inc. Taxes	21.8%	38.5%
Net savings after Fed. Inc. Taxes (at 52%)	$2,505	$4,440
Return after Federal Inc. Taxes	10.4%	18.5%
Pay out time (after deprec. & Fed. Taxes)	9.6 yrs.	5.4 yrs.

Whether you require a complete Fluidization system or merely system components, Flo-Tronics can custom-build to your specifications or requirements. For an engineering evaluation of your material handling requirements—or simply a discussion of your needs with your own engineers, write or call Mr. William P. Edmunds, Dept. 101.

FLO-TRONICS INC
1420 zarthan avenue
minneapolis 16, minn

BOOKSHELF . . .

Advances in Organic Chemistry: Methods and Results. Vol. 2. Ed. by R. A. Raphael, E. C. Taylor and H. Wynberg. Interscience Publishers, New York. 504 pages. $15.00. Several new fields of investigation are presented that may offer new tools and desirable intermediates for synthetic work in organic chemistry. Chapters include: Alkenylmagnesium Halides, Dialkoxydihydrofurans and Diacyloxydihydrofurans as Synthetic Intermediates, Ethynyl Ethers and Thioethers as Synthetic Intermediates, Ketene in Organic Synthesis, Nuclear Magnetic Resonance in Organic Structural Elucidation.

Heterocyclic Chemistry. By A. R. Katritzky and J. M. Lagowski, John Wiley and Sons, New York. 274 pages. $4.75. This book on heterocyclic chemistry was designed primarily for advanced undergraduate students. It contains a condensed cross-section of the various heterocyclic systems with emphasis on the application of electronic theory as applied to aliphatic and aromatic chemistry. Syntheses of compounds are included, along with discussions of the reactions of the aromatic rings, as well as reactions of substituents on the aromatic nuclei.

And Also Received

The Physical & Thermodynamic Properties of Helium. First out in 1957, study has been updated in a new 84-page booklet that summarizes current data. 18 tables and a bibliography are included. Write: Whittaker Controls., div. of Telecomputing Corp., 915 N. Citrus Ave., Los Angeles 38, Calif. $10.

The Science Book List for Children. Compiled by H. J. Deason, consultant R. N. Foy. The Science Library Program of The American Assn. for the Advancement of Science, aided by an annual grant from the National Science Foundation, has come up with a 138-page booklet intended to aid your purchase of science literature for children in first through eighth grades. Books are listed under subject matter (eg., encyclopedias and general works; science in general; experiment books; individual sciences (chemistry, astronomy, zoology, etc.). Author(s), publisher, year of publication, number of pages and price are given. And three categories are set up as to content difficulty: P = primary or very simple; I =

intermediate; A = advanced. A one-sentence description outlines content, and an asterisk system makes recommendations. Number of books in the rundown: 1,105. Single copies of this list are available for $1. Write: American Assn. for the Advancement of Science, 1515 Massachusetts Ave., N. W., Washington 5, D.C.

Proceedings of the Organic Cooled Reactor Forum. The October 1960 proceedings are recapped in a dozen papers. Topics include: status of organic coolant technology; status of heat transfer development for organic reactor; status of process development for organic reactor. For details, write: Atomics International, Div. of North American Aviation, Inc., P. O. Box 309, Canoga Park, Calif.

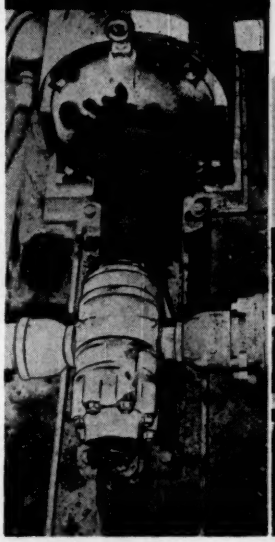
Scientific and Technical Personnel in American Industry. Report on a 1959 survey. Prepared for the National Science Foundation by the Bureau of Labor Statistics, U. S. Dept. of Labor, this is a 66-page preliminary totting up. The sample encompassed over 10,000 firms, and estimates were obtained not only on the numbers of scientists, engineers and technicians employed in industry but also, for the first time, on the number of companies utilizing such personnel. Another innovation—of importance in assessing the current and future demand for personnel in these professions: the information obtained on the numbers of scientists and engineers primarily engaged in research and development, management, production, and other functions. Final report will appear later this year. For copy of preliminary report, write: Supt. of Documents, U. S. Govt. Printing Office, Washington 25, D. C. Price 45¢.

More New Books

Symposium on Air Pollution Control. American Soc. for Testing Materials, 1916 Race St., Philadelphia 3, Pa. $1.50 (members, $1.20).

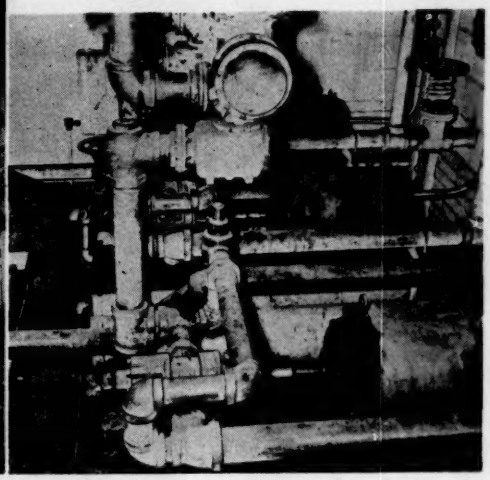
Surface Microtopography. By S. Tolansky. Interscience. $9.

5
Sier-Bath
GEAREX®
PUMPS

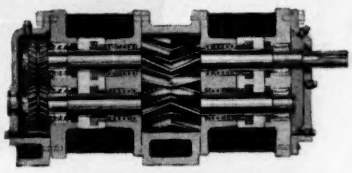


Pumping Hot Varnish 10 Years
--not one cent for repairs!
At DE SOTO CHEMICAL COATINGS CORP.

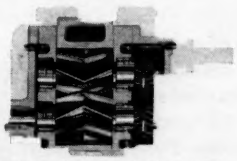
The only maintenance in 10 years has been several tightenings of the original packing, still in use without leakage. The Gearex Pumps are transferring 35 gpm. of hot varnish from tank trucks to storage tanks 5 hours a day. Varnish has a viscosity of 1800 to 7000 SSU at 70° to 160° F., pumped at 150 psig. De Soto is highly pleased with fast transfer service and complete absence of repair costs and shutdown losses.



Sier-Bath "Gearex" Pumps



EXTERNAL GEAR & BEARING TYPE
for non-lubricating liquids

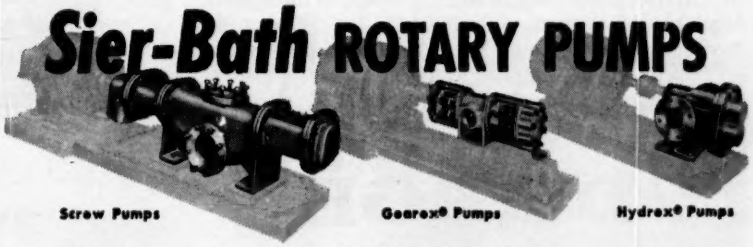


INTERNAL GEAR & BEARING TYPE
for lubricating liquids

Sier-Bath "Gearex" Pumps provide positive displacement, pulseless flow . . . quiet, vibrationless operation. Direct-connected up to 1800 RPM, they require no reduction gears. For high volumetric efficiency and long life there is no rotor-to-rotor or rotor-to-casing contact. Low pressure on stuffing boxes provides easy servicing.

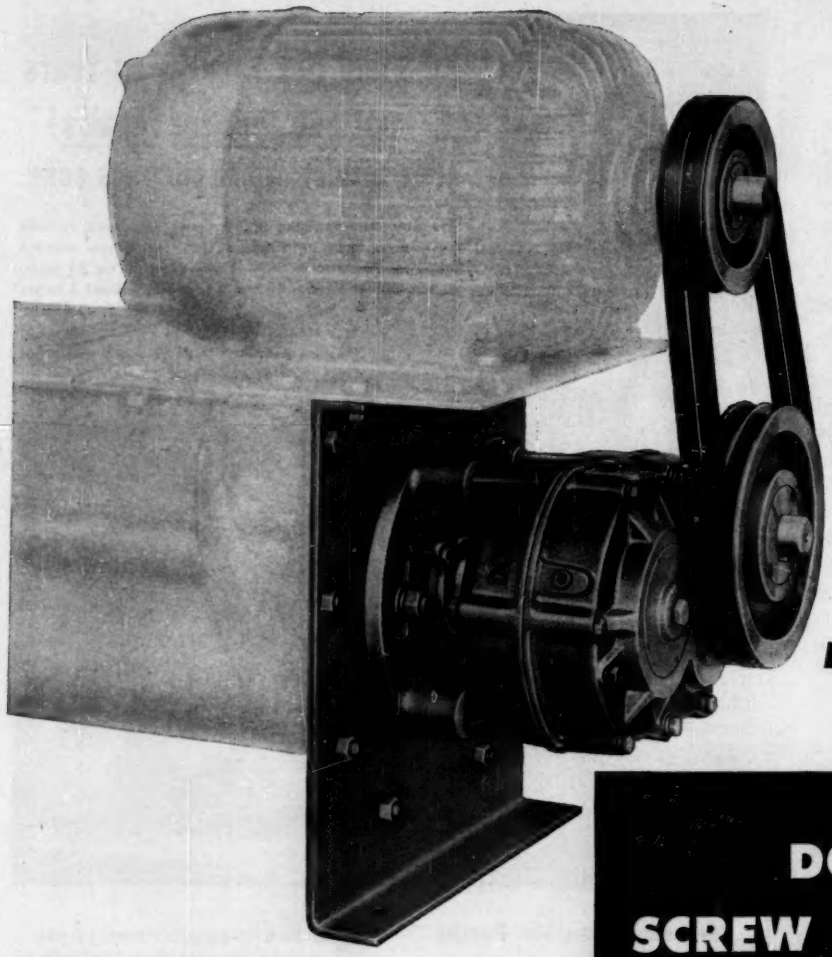
Horizontal or vertical models to handle 32 to 5,000,000 SSU, 1 to 650 GPM, at pressures up to 350 psi. Corrosion-resistant alloys, steam-jacketed bodies, water-cooled bearings, other adaptations to meet individual needs. See "Yellow Pages" for your local Sier-Bath Pump Representative or send for Bulletin G-3. *Sier-Bath Gear & Pump Co., Inc., 9259 Hudson Blvd., North Bergen, N. J.*

Sier-Bath ROTARY PUMPS



Screw Pumps | Gearex® Pumps | Hydrex® Pumps

Founded 1905 | Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings | Member A. G. M. A.



Entirely New!

Entirely Different!

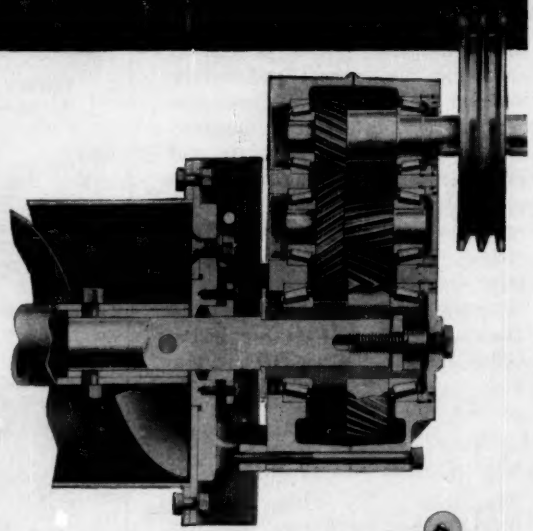
DODGE SCREW CONVEYOR DRIVE

A complete package drive, including

- **Rugged, high-efficiency Reducer.**
- **Quick-removable Driving Shaft.**
- **External Packing Gland.**
- **Trough End (optional).**

Amazing new ease of installation—new ease of maintenance—new economy! No external thrust bearing or motor base is necessary. (However, a motor base of special design is available as optional equipment.) Pre-selected Taper-Lock V-Belt drives give required speeds. Built-in puller makes it easy to change driving shaft—without opening reducer. External packing gland protects reducer. Helical steel gears. Timken Bearing equipped throughout. Available from stock with 1½", 2", 2 7/16", 3" and 3 7/16" driving shafts. Ask your Dodge Distributor, or write us for bulletin giving complete technical data.

DODGE MANUFACTURING CORPORATION, 200 Union, Mishawaka, Ind.



DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Equipment."

Letters: Pro & Con

Ghosts of the Past

Sir:

At regular intervals, on reading your publication, it seems that ghosts of my past return to haunt me. So it was with your Oct. 31 issue, in which there were not one, but two such ghosts. I refer to your *Chementator* item on continuous production of titanium dioxide (p. 41) and to your remarks on the corrosion resistance of thick chromium plate (p. 140).

On the first subject, I refer you to a letter of mine published in your Oct. 20, 1958, issue (pp. 213-214), commenting on an item in your Aug. 25, 1958, issue.

As to the second subject, the corrosion resistance of thick chromium plate was the subject of one of my investigations while employed at Electrolux Ltd., Luton, England, 1937-39. This work also showed that a thick chromium plate gave marked superior corrosion resistance. We were considering the purchase of the extra plating area needed to obtain the desired rate of production when the outbreak of war temporarily eliminated the production of refrigerators, floor polishers and the like.

A. A. MAYLING
Denison Mines Ltd.
Elliot Lake, Ont.

▶ *Mr. Mayling's* 1958 *references concerned a news story we ran about work being done in Australia on the continuous digestion of ilmenite with sulfuric acid, followed by Mr. Mayling's reminiscences about similar work done in England on a commercial scale* 15-20 *years earlier.*—ED.

Pro: Oxygen in Steel

Sir:

I read with a great deal of interest your article, "Oxygen Keeps Steel in Turmoil" (Nov. 28, pp. 77-78).

Although you failed to mention Air Reduction, we are one of the largest suppliers of oxygen to the steel industry and have recently formed a "tonnage gas" sales department for the marketing of on-site plants to supply the steel and chemical industries. We have plans for several on-site plants on the drawing boards.

JOHN J. JOHNSTON
Air Reduction Sales Co.
New York, N. Y.

Pro: Piping Materials

Sir:

My compliments to you on your Materials of Construction issue (Nov. 14). The article on materials for process piping was very good, impartial, and will be most helpful to chemical engineers.

Also the directory of material manufacturers and the inventory of manufacturers' literature will be excellent reference material for any chemical engineer to have.

P. M. REYNOLDS
Corning Glass Works
Corning, N. Y.

A Cement Shortage?

Sir:

Your article on the cement outlook in the Oct. 31 issue (pp. 60-64) was indeed well done. There is one question I wish to raise about the chart on p. 60.

As a relative newcomer to the cement industry, I have received a rather vivid impression from listening to the conversation of industry veterans about that period fondly referred to as the "shortage" era. During this postwar era and into 1956, so I am told, demand for cement substantially exceeded supply.

Your chart indicates something like 30 to 40 million barrels of capacity in excess of shipments. If this "shortage" did, in reality, exist during the 1950-1956 period, and if that capacity existed, then we would have to assume that the capacity was allowed to remain idle.

I can conceive of two possible explanations:

• The excess capacity did exist physically but was so antiquated

NEW! DYNA-V DRIVES
Save space, weight and cost!

DODGE PARA-FLEX
The Flexible Cushion Coupling
with the 4-way flex!

FLEXIDYNE
The Dry Fluid Drive
New soft starts—overload protection

•

Write for Bulletins!

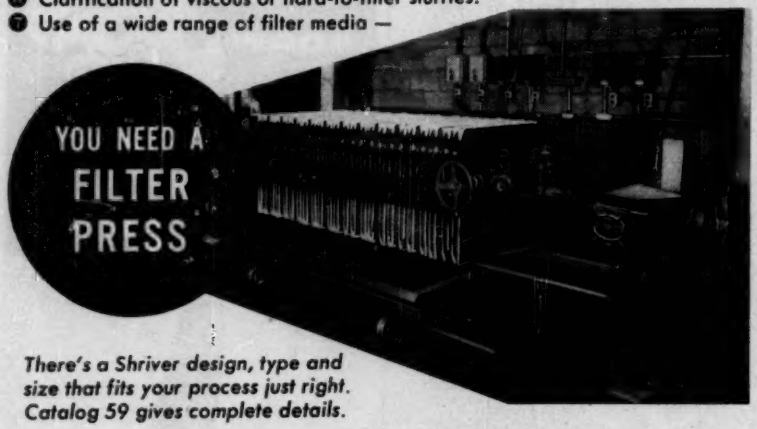
- Dyna-V Drives—selection data.
- Para-flex Couplings—data.
- Flexidyne Drives & Couplings.

DODGE MANUFACTURING CORPORATION
200 Union Street • Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

WHEN YOU REQUIRE FILTRATION

1. That is versatile and flexible in operation,
2. Over a wide range of pressures,
3. For recovery of filtrate and of uniform, dense filter cake,
4. With effective washing or extraction of cake.
5. No left-over slurry at end of run.
6. Clarification of viscous or hard-to-filter slurries.
7. Use of a wide range of filter media —



There's a Shriver design, type and size that fits your process just right. Catalog 59 gives complete details.

WHEN YOU REQUIRE FILTRATION

1. Of slurries with a low percentage of compressible and disposable solids or
2. Of slurries with up to 15 percent of solids, with either or both filtrate and solids to be recovered.
3. Where continuous filter aid additions are required to maintain a permeable filter cake.
4. Where residual solids may be reslurried with water for disposal.
5. Where an enclosed tank is needed to avoid leakage.
6. With one-man operation for sluicing, cleaning and preparation for the next cycle —

The Shriver vertical leaf filter is available in vertical tank and horizontal tank types, in a wide range of leaf and tank sizes. New Bulletin 150 tells the story.

FILTERS AND COMPLETE FILTER STATIONS TO MEET YOUR EXACT PROCESSING NEEDS

T. Shriver & Company, Inc.

802 HAMILTON STREET • HARRISON, N. J.

Sales offices in principal cities

PRO & CON . . .

that it could not be operated economically. In this case, one might doubt the validity of classing it as "capacity."

• The cement industry overrated its capacity by 30-40 million barrels annually and, when forced with peak demand, the excess rating became evident.

Perhaps there is another explanation of which I am unaware. In any event, I would be most interested in your observations on this point.

WILLIAM J. COCHRAN
American Cement Corp.
Detroit, Mich.

► *Our statistics came from the Minerals' Yearbook, published by the U. S. Dept. of the Interior. If there is a discrepancy, it is between producers who remember "shortages" and government statisticians who estimate "capacity."*

Either of Mr. Cochran's suggested explanations might in fact be correct. Anyone else able to explain this situation?—ED.

CE's History

Chemical Engineering, with which is incorporated *Chemical & Metallurgical Engineering*, is the successor to *Metallurgical & Chemical Engineering*, which in turn was a consolidation of *Electrochemical & Metallurgical Industry* and *Iron & Steel Magazine*.

The magazine was originally founded as *Electrochemical Industry*, in September 1902, and was published monthly under the editorial direction of Dr. E. F. Roeber. It continued under that title until January 1905, when it was changed to *Electrochemical & Metallurgical Industry*. In July 1906, the consolidation was made with *Iron & Steel Magazine*, which had been founded eight years previously by Dr. Albert Sauveur. In January 1910, the title was changed to *Metallurgical & Chemical Engineering*, and semi-monthly publication was begun Sept. 1, 1915. On July 1, 1918, the title was changed to *Chemical & Metallurgical Engineering* and weekly publication was begun Oct. 1, 1919. Monthly publication was resumed in March 1925.

In August 1946, the words "*& Metallurgical*" were dropped from the main title to bring its name more in keeping with the editorial content. Biweekly publication began in January 1958.

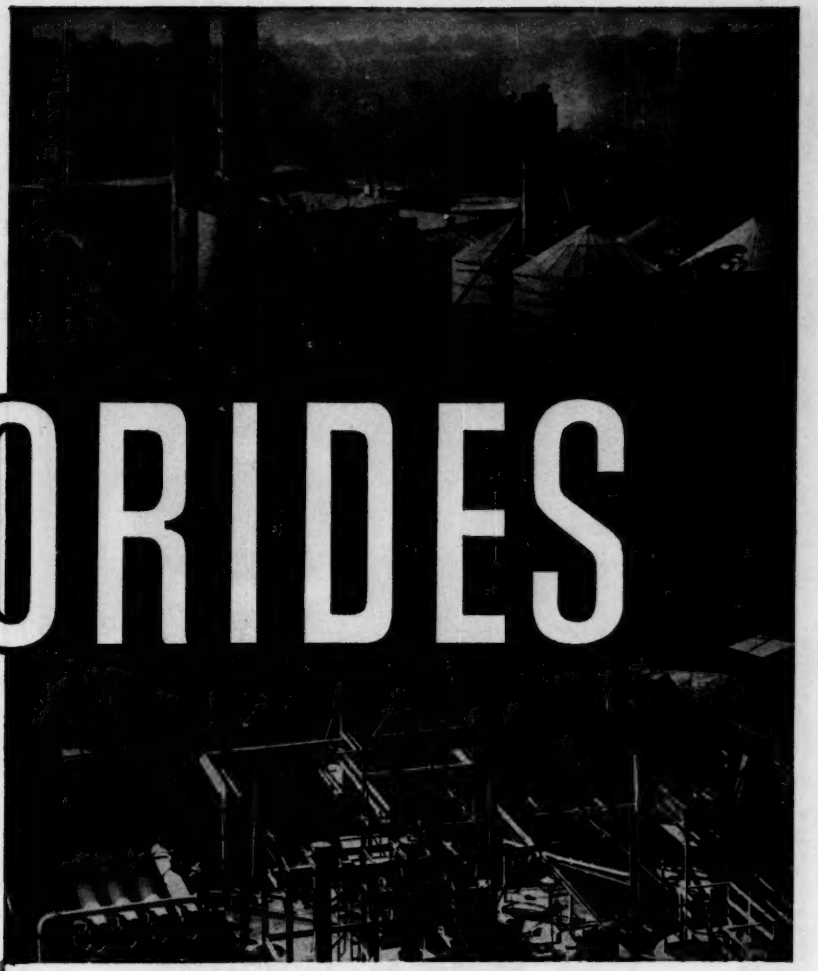
Dr. E. F. Roeber was editor of the paper from the time it was founded until his death Oct. 17, 1917. After a brief interim he was succeeded by H. C. Parmelee. Ten years later, Nov. 1, 1928, Sidney D. Kirkpatrick was appointed editor.

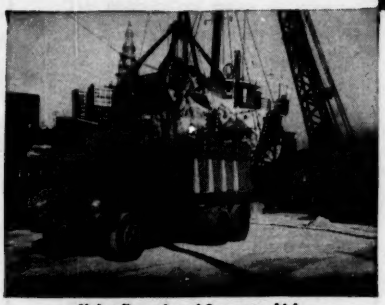
On May 1, 1950, Dr. Kirkpatrick was named editorial director, a post he filled until his retirement, and John R. Callaham succeeded him as editor. On Sept. 1, 1959, Mr. Callaham assumed the duties of a vice president of the McGraw-Hill Publishing Company. He was succeeded as editor in chief by Cecil H. Chilton.

[All rights to above magazine titles reserved by the publisher.]

HARSHAW

FLUORIDES





Unloading mineral fluospar which comes to us from various parts of the world.

HARSHAW'S MANUFACTURED PRODUCTS INCLUDE:

CATALYSTS
CERAMIC COLORS
DYES & FINE ORGANIC CHEMICALS
FLUORIDES
METALLIC SOAPS & SALTS
SYNTHETIC OPTICAL CRYSTALS
PIGMENTS
PLATING CHEMICALS
PLASTIC STABILIZERS

SILICON TETRAFLUORIDE
ANOTHER FIRST FOR HARSHAW

Harshaw's newest fluoride is silicon tetrafluoride. One of the major oil companies has just developed a process for sealing water out of oil wells during drilling with this newly introduced fluoride.

In 1904 when The Harshaw Chemical Co. first started to manufacture hydrofluoric acid, all of the production was used by foundries to remove sand from iron castings. Today, Harshaw's fluoride division produces 26 different fluoride chemicals for as many industries.

The major uses of Harshaw Fluorides are in the petroleum, glass, steel, and atomic energy industries. Even in these industries the uses are diversified. The versatility of Harshaw fluorides is also evident by their use in soldering fluxes, cleaning boilers, removing iron stains and souring laundry, curing plastics, alloying aluminum, floating minerals, sanitizing breweries, and treating water.

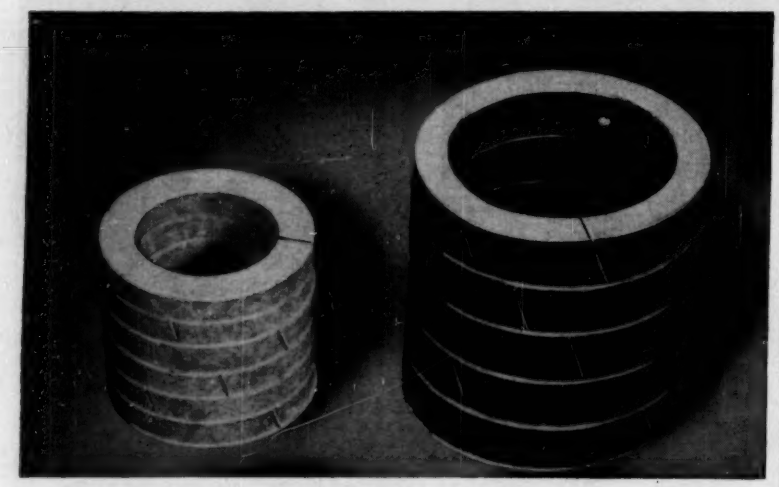
The Harshaw Chemical Company

1945 EAST 97TH STREET • CLEVELAND 6, OHIO

HARSHAW'S 5 MANUFACTURING PLANTS

Cleveland, Ohio • Elyria, Ohio • Gloucester City, N.J.
Hastings-On-Hudson, N.Y. • Louisville, Ky.

STILL THE *No. 1* TEFLON* SHAFT PACKING FOR PUMPING CORROSIVES



...CHEMPRO STYLES 101 and 201

(THE ORIGINAL TEFLON SHAFT PACKING)

Chempro Styles 101 and 201 Teflon Shaft Packings, although developed and perfected over 10 years ago, are still the most popular Teflon shaft packings for pumps handling highly corrosive products.

These two stuffing box packings drastically cut packing replacement and maintenance costs. Styles 101 and 201 last for months under corrosive conditions where ordinary packings fail in days and even hours. Successfully seals against bromine, chlorine, butyl extracts, sulphur dioxides, concentrated sulphuric acid, aqua regia, thionyl chloride and organic solvents including halogenated hydrocarbons, etc.

Ideal for use on either centrifugal or reciprocating pumps, at speeds up to 3600 R.P.M. and at temperatures ranging from —118°F. to +525°F.

STYLE No. 101 — Compounded of approximately 94% shredded Teflon and a graphite friction reducer, molded into packing rings.

STYLE No. 201 — Same as No. 101 except that mica is used as the friction reducer.

Both styles are made in sizes to fit any stuffing box. Supplied in ring sets for specific equipment or in single quantity ring orders.

Write for Chempro Bulletin CP 552.

*duPont Trademark

CHEMICAL & POWER PRODUCTS, INC.
5 Broadway, New York 4, N. Y.

The Original Fabricators of Teflon Packings and Gaskets

TIMELY
HELPFUL
FREE . . .

Timely, helpful, free. That's the kind of data, information and technical know-how that CE's Reader Service section can bring you.

Help yourself in this supermarket of ideas. All you need is a pencil and a postcard.

Here's what's available: More information on any advertised products or service; Latest technical literature (p. 172); Additional details on new chemicals and equipment described in this issue (pp. 58-64).

As you read this issue—pencil in hand—circle numbers on your Reader Service card. Your selections will be mailed to you promptly by the manufacturers. It's a mighty handy way to keep up-to-date with what's new in processes and products.

And why not take advantage of our offer of a free reprint for your files. Just put a check mark in the free reprint box on the card.

Chemical Engineering
Reader Service

STARTS RIGHT HERE ▸

For more information . . .

- Advertised Products
- New Equipment
- New Chemicals
- Manufacturers' Literature
- Classified Advertisements

Also . . .
- Reprints orders
- Subscriptions

Your Reader Service card is fastest.

USE EITHER CARD

They're easy to fold and tear out . . . try it . . .

PLEASE PRINT ✻

NAME:
TITLE:
COMPANY:
NO. OF EMPLOYEES:
PRODUCT:
ADDRESS:
CITY, STATE:

FIRST CLASS
PERMIT NO. 64
(Sec. 34.9 P.L.&R.)
NEW YORK, N. Y.

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

—POSTAGE WILL BE PAID BY—

Chemical Engineering
READER SERVICE DEPARTMENT
330 West 42nd St.
NEW YORK 36, N. Y.

PLEASE PRINT ✻

NAME:
TITLE:
COMPANY:
NO. OF EMPLOYEES:
PRODUCT:
ADDRESS:
CITY, STATE:

FIRST CLASS
PERMIT NO. 64
(Sec. 34.9 P.L.&R.)
NEW YORK, N. Y.

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

—POSTAGE WILL BE PAID BY—

Chemical Engineering
READER SERVICE DEPARTMENT
330 West 42nd St.
NEW YORK 36, N. Y.

Help Yourself . . .

The postcards above can now bring you technical help, latest literature, expert guidance. Tear one out and, as you read this issue, circle numbers when you want more information. You'll note that the coding system is simple: all the code numbers are page numbers.

You can also use these post-paid cards to subscribe, or to make your selection from a comprehensive list of editorial reprints.

✻ **Be sure to fill in all of these address blanks before mailing postcard.**

Send CE for ☐ 1 yr. $3, ☐ 3 yr. at $5 (U.S. rate only.) 1

To _____

CIRCLE code numbers for more information. (This Jan. 9 issue card will expire April 9, 1961)

Cov.	16-17	55c	62G	72	136e	144	154A	163	173F	176B	180E	184A	185G	190B
1	18-19	55d	62H	73	137	145	155	164	173G	176C	180F	184B	185H	190C
2a	20-21	55e	63	79	138	146	156	165	174	176D	180G	184C	T186	190D
2b	22-23	55f	64A	80	139a	147	156A	166a	174A	176E	L181	184D	B186	190E
2c	24-25	55g	64B	81	139b	148	157	166b	174B	176F	R181	184E	186A	190F
2d	26-27	57	64C	82	139c	148A	157A	167	174C	176G	181A	184F	186B	190G
2e	28	58A	64D	119	139d	148B	158	168	174D	176H	181B	L185	T187	198a
2f	29	58B	65	123	139e	149	158A	172	174E	176I	181C	R185a	B187	198b
2g	30	58C	66A	125	139f	149A	158B	172A	174F	176J	181D	R185b	187A	198c
2h	31	59	66B	127	139g	150	158C	172B	174G	177	181E	R185c	187B	198d
4	32	60A	67	129a	139h	150A	158D	172C	174H	178	T182	R185d	187C	198e
6-7	34	60B	68A	129b	139i	150B	158E	172D	174I	178A	B182	R185e	T188	198f
8-9	41	60C	68B	131	139j	151	159	172E	174J	179	182A	R185f	B188	199
10-11	45	61	68C	133	139k	152	159A	172F	174K	L180	T183	185A	188A	L200
12-13	47	62A	68D	135	139l	152A	159B	173A	174L	R180	B183	185B	188B	R200
14-15a	49	62B	69	136a	140	153	159C	173B	174M	180A	183A	185C	189	201
14-15b	51	62C	71a	136b	141	153A	160	173C	175	180B	183B	185D	189A	202
14-15c	53	62D	71b	136c	142	153B	161	173D	176	180C	L184	185E	190	203
14-15d	55a	62E	71c	136d	143	154	162	173E	176A	180D	R184	185F	190A	204
14-15e	55b	62F												

Circle KEY NUMBERS for more information about . . .

- ADS
- PRODUCTS page 58
- EQUIPMENT page 64
- SERVICES
- LITERATURE page 172

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

- CLASSIFIED

REPRINTS: Circle what you want. (See opposite page for description.)

40	42	45	49	50	52	54	55	57	59	61	62	63	64	66	67	68	70	72	73	74	75
76	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
100	101	102	103	105	107	108	109	110	111	112	113	114	115	117	118	119	120	121	122	123	124
125	126	127	128	129	130	131	133	135	136	138	139	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170		

FREE REPRINT: Check here ☐ for your file copy of this issue's reprint (p. 120) FC 53

REPRINTS (While they last)

Send CE for ☐ 1 yr. $3, ☐ 3 yr. at $5 (U.S. rate only.) 1

To _____

CIRCLE code numbers for more information. (This Jan. 9 issue card will expire April 9, 1961)

Cov.	16-17	55c	62G	72	136e	144	154A	163	173F	176B	180E	184A	185G	190B
1	18-19	55d	62H	73	137	145	155	164	173G	176C	180F	184B	185H	190C
2a	20-21	55e	63	79	138	146	156	165	174	176D	180G	184C	T186	190D
2b	22-23	55f	64A	80	139a	147	156A	166a	174A	176E	L181	184D	B186	190E
2c	24-25	55g	64B	81	139b	148	157	166b	174B	176F	R181	184E	186A	190F
2d	26-27	57	64C	82	139c	148A	157A	167	174C	176G	181A	184F	186B	190G
2e	28	58A	64D	119	139d	148B	158	168	174D	176H	181B	L185	T187	198a
2f	29	58B	65	123	139e	149	158A	172	174E	176I	181C	R185a	B187	198b
2g	30	58C	66A	125	139f	149A	158B	172A	174F	176J	181D	R185b	187A	198c
2h	31	59	66B	127	139g	150	158C	172B	174G	177	181E	R185c	187B	198d
4	32	60A	67	129a	139h	150A	158D	172C	174H	178	T182	R185d	187C	198e
6-7	34	60B	68A	129b	139i	150B	158E	172D	174I	178A	B182	R185e	T188	198f
8-9	41	60C	68B	131	139j	151	159	172E	174J	179	182A	R185f	B188	199
10-11	45	61	68C	133	139k	152	159A	172F	174K	L180	T183	185A	188A	L200
12-13	47	62A	68D	135	139l	152A	159B	173A	174L	R180	B183	185B	188B	R200
14-15a	49	62B	69	136a	140	153	159C	173B	174M	180A	183A	185C	189	201
14-15b	51	62C	71a	136b	141	153A	160	173C	175	180B	183B	185D	189A	202
14-15c	53	62D	71b	136c	142	153B	161	173D	176	180C	L184	185E	190	203
14-15d	55a	62E	71c	136d	143	154	162	173E	176A	180D	R184	185F	190A	204
14-15e	55b	62F												

Circle KEY NUMBERS for more information about . . .

- ADS
- PRODUCTS page 58
- EQUIPMENT page 64
- SERVICES
- LITERATURE page 172

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

- CLASSIFIED

REPRINTS: Circle what you want. (See opposite page for description.)

40	42	45	49	50	52	54	55	57	59	61	62	63	64	66	67	68	70	72	73	74	75
76	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
100	101	102	103	105	107	108	109	110	111	112	113	114	115	117	118	119	120	121	122	123	124
125	126	127	128	129	130	131	133	135	136	138	139	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170		

FREE REPRINT: Check here ☐ for your file copy of this issue's reprint (p. 120) FC 53

REPRINTS (While they last)

For Subscriptions: To apply, check here .....
(Pay when billed) Where to send subscriptions .....

Want More Data?

Use this postcard for catalogs . . . for more information on equipment . . . on materials . . . on advertised items . . . for helpful reprints of editorial articles. Be sure to fill out the other side of cards. *Important—For pages showing more than one advertised item, use this guide to numbers on cards above.*

2a—Centrifugals

2b—Centrifugals, Compact

2c—Centrifugal, Screen Type

2d—Rotary Drum Filter

2e—Rotary Vacuum Filter

2f—Centrifuge, Oscillating

2g—Filter, Leaf

2h—Centrifuge, Suspended Batch

71a—Fluorolubes

71b—Sulfur Dichloride

71c—Lauryl Mercaptan

R185a—Safety Equipment

R185b—Stainless Drum Faucets

R185c—Drum Transfer Pump

R185d—Oval Shape Safety Cans

R185e—Flammable Storage Cabinet

R185f—In-Line Flame Arrester Vents

Use this handy coupon to order your personal subscription to Chemical Engineering.
No need to send any money now. We'll bill you later.

Reprints Now Available

CE editorial reprints are now easy to get—use Reader Service Card for fast service. For each reprint you want just circle its number on the card. Fill in the blanks on the front, mail. You may send remittance if you wish.

• Materials of Construction

Corrosion—Refresher on cause & cure ($1).....131
High-Temperature Materials—Inorganic, nonmetallic (75¢) 120
High-Temperature Metals—Selection, directory ($1).....129
Lead Installations—Best designs for many uses (50¢)..... 79
Nonmetallic Inorganics—For severe conditions (50¢)....125
Plastic Pipe—How and when to use (75¢).....135
Process Piping Materials—Selection, directory ($1).....169
Protective Linings—Choice, application, directory ($1).... 88

• Equipment and Design

Air Pollution—CPI plant solutions (50¢).....143
Control Valves—Behavior and selection (75¢).....141
Estimating Engineering Properties
Thermal Conductivity (50¢) 94
Heat Capacities (75¢).109
Latent Heat (75¢)....117
Surface Tension (75¢).126
Viscosity (75¢) 138
Critical Properties (75¢).149
Other Physical Properties (50¢) 151
Flowsheets—Engineering communiques (50¢)..... 99
Flow File—50 design formulas (50¢).....112
Flow Through Packing and Beds
Packed Towers (50¢).....103
Fixed and Moving Beds (50¢).....107
Fluidized Systems (50¢).....108
Heat Exchanger Design—Shortcut methods (75¢)..... 52
Heat Exchanger Calculations—Use these charts ($1)....136
Instruments—"Hardware" section of Report 95 (50¢).... 96
Mechanical Seals—How to select and use (50¢)..... 83
Piping—Roundup of process pipe, valves, fittings (75¢)... 40
Process Design: Fluid Flow—Size lines, pick pumps ($1)..161
Process Control—Instrumentation report ($1)..... 95
Pump Seals—Chemical plant practice (50¢)..... 92
Water Conservation—Will taps run dry? (50¢).....105
Water Pollution—Solve plant problems (50¢).....122
Your Design Reference File
Parts I-V (75¢).....100
Parts VI-IX (75¢).....110

• Processes

Biochemicals Processing—The total picture (50¢)..... 93
Bio-oxidation—Treatment of wastes (50¢)..... 68
Chemicals from Petroleum—Available processes ($1)....139
Extractive Metallurgy—By chemical processing (50¢)....111
Ultra-Low Temperatures—Production and uses (50¢).....133
Fermentation—Its chemical technology (50¢)..... 74
High-Temperature Technology—Materials, processes (50¢) 91
Manufactured Gas—To supplement natural gas (50¢)....115
Moving Bed Processes—Theory plus application (75¢)..... 64
Nuclear Industry—Role of chemical engineers (50¢)..... 89
Nuclear Wastes—Treatment and disposal (50¢).....150
Odor Control—How to be a good neighbor (50¢)..... 98
Operation & Maintenance—The impact of trends ($1)....121
Photochemical Engineering—Uses, processes, reactors (75¢) 59
Plants & Facilities—Inventory of 1959 (75¢).....158
Processes & Technology—Eighth Inventory 1958 (50¢)...118
Processes & Technology—Ninth Inventory 1959 (50¢)....159

• Costs and Commerce

Buyer-Seller Relations—Vendor's view (50¢).....157
Capital Cost Estimating—Data, sources & methods ($1)...156
CE Cost File—Quick estimating data (50¢).....153
Cost Control Systems—Reduce and control costs (50¢)....102
Inflation—How to predict a shrinking dollar (50¢)..... 78
Modernization—Tighten up for profits (75¢).....128
Patent Fundamentals—Timely review (50¢).....114
Petrochemicals—1958 economic review (50¢).....123
Process Energy—Make or buy? (50¢).....142
Professional Registration—For PE-Minded ChE's (50¢)... 85
Rockets and Missiles—Airborne reactor problems (75¢)...119
60's Challenge Chemical Engineers (50¢).....152

• Unit Operations

Absorption With Chemical Reaction—(50¢).....162
Adsorption—Design, methods, materials (50¢).....154
Azeotropic Separation—Close-boiler distillation (50¢)....160
Binary Distillation—Theory, equipment (75¢)..... 54
Compressible Fluids—How to handle ($1)..... 80
Crystallization—For purification (50¢).....124
Drying—Methods, equipment, design, costs (75¢)..... 70
Foams—How to use and control (50¢)..... 86
Ion Exchange—Process, design and applications (75¢).... 55
Liquified Compressed Gases—Handle with care (50¢)....147
Liquid-Gas Contacting—A practical operation study (75¢). 82
Liquid Proportioning—Equipment, methods, uses (50¢)... 76
Lubrication—For chemical plant engineers (50¢)..... 50
Solids Concentration—Survey of techniques (50¢)..... 67
Solids-Gas Contacting—Commercial practice (50¢)..... 63
Solids-Liquid Separation—Unit operations description ($1). 62
Solid-Solid Blending—Theory, practice, equipment (75¢).163

• Chemical Engineering Science

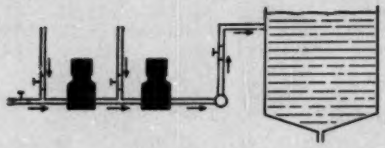
Analog & Digital Computers—In engineering use (50¢)...145
Speculative Process Design—Pilot plant bypass (50¢)....146
Pilot Plant—All the aspects of scale up ($1).....127
Statistics—How to use data effectively (75¢)..... 73
CE Refresher
Thermodynamic Principles (50¢)..... 42
Compression & Expansion (50¢)..... 45
Chemical Equilibrium (50¢)..... 49
Homogeneous Kinetics (50¢)..... 57
Catalytic Kinetics (50¢)..... 61
Interpreting Kinetics (50¢)..... 66
Simple Reactor Design (50¢)..... 72
Complex Reactor Design (50¢)..... 75
Catalytic Reactor Design (50¢)..... 81
Reactor Design Problems (50¢)..... 87
Physical Equilibrium I (50¢)..... 90
Physical Equilibrium II (50¢)..... 97
Fluid Flow Equations (50¢).....101
Fundamental Math (75¢).....113
Mass Transfer Operations ($1).....130
Unit Operations Refresher
Fluid Flow (50¢).....144
Sedimentation Theory (50¢).....148
Heat Transfer (50¢).....155
Unsteady State Heat Transfer (50¢).....164

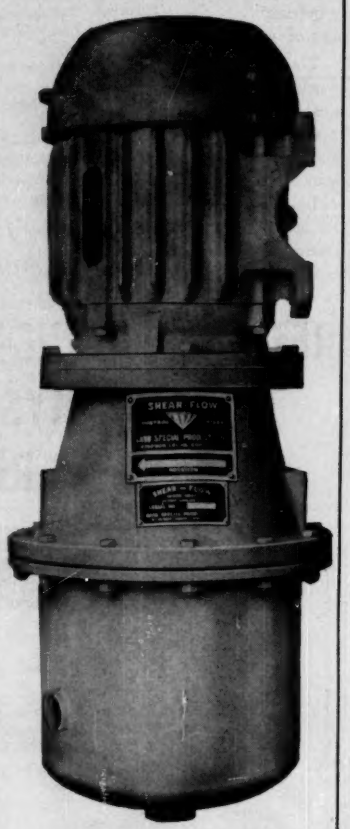
Recent Reprints—to keep your files up-to-date.

Absorption Methods—Unit operation refresher (50¢)...168
CPI Forecast for '61 (50¢).....170
Packaging—Unit containers for chemicals (50¢).....166
Plants & Facilities—Semiannual inventory (50¢).....167
Plant Startups—Systematic preparation (50¢).....165

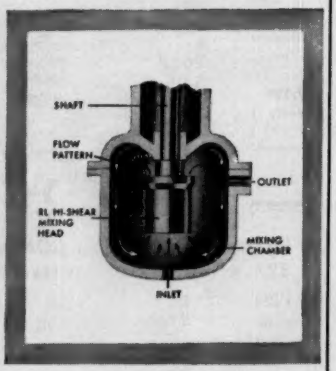
NEW SHEAR-FLOW CONTINUOUS MIXER

Finer, faster blending for in-line processing





- **CUT PROCESSING COSTS:** This compact and completely self-contained unit conserves space, eliminates large mixing and paddle tanks, speeds up pipe line processing, handles high viscosity material in a minimum of time and conveniently lends itself to systems requiring jacketed heating or cooling.
- **ELIMINATE COSTLY EQUIPMENT:** Incorporating the same design principle as the portable SHEAR-FLOW, the new continuous mixer is capable of mixing any liquid that can be pumped, with results better than or comparable to that of equipment costing considerably more.
- **VERSATILE ADAPTABILITY:** More than one unit can be installed in series or in tandem along the route of flow. The new continuous SHEAR-FLOW can also be mounted either vertically or horizontally.
- **HI-SHEAR HEAD:** The unique Hi-Shear Head with dual impellers and stationary stators creates a high turbulence and concentrated shearing action that results in finer, faster blending, homogenizing, emulsifying or dispersing. Mechanical shear is achieved through close tolerances between impellers and stators.
- **SIZE RANGE:** The new SHEAR-FLOW can be powered with motors ranging from 1 to 10 horsepower depending on the power requirement demanded by the application.



Write for free Bulletin No. RL-200

SHEAR-FLOW
GABB SPECIAL PRODUCTS INC.

GABB SPECIAL PRODUCTS INC.
Windsor Locks, Conn.

Manufacturers' Literature

Contents of This Issue

Chemicals	172
Construction materials	178
Electrical & mechanical	178
Handling & packaging	180
Heating & cooling	182
Instruments & controls	183
Pipe, fittings, valves	184
Process Equipment	186
Pumps, fans, compressors	189
Services & miscellaneous	190

Chemicals

Adhesives.....Selector guide chart shows properties of manufacturers adhesives and hardners; includes tensile shear strengths, operating temperature ranges, etc.
172A Hysol Corp.

Aerosol Reagents.....Spraytec reagents are stable, protected from deleterious effects of light and air, and are economical. Produces a fine uniform spray.
172B Mann Research Laboratories

Aliphatic Amines....Booklet gives composition, complete specifications, physical properties reactions and other data for primary, secondary and tertiary amines.
172C Armour Industrial Chemical Co.

Alloys.....Information about the properties & corrosion resistance of Alloy C and other Hastelloy alloys is contained in a booklet which is available.
131 *Haynes Stellite Co.

Asbestos Fibre....18-page booklet gives step-by-step descriptions of 15 standard testing procedures to determine characteristics of commercial grade asbestos fibre.
172D American Smelting & Refining Co.

Catalyst Carriers.....Macroport "A" are currently available as spheres, pellets, and aggregate of fused aluminum oxide. Complete details on Macroport "A" carriers.
29 *Norton Company

Cationic Chemicals.....Use of cationic chemicals in paints and pigment production discussed in pamphlet that also explains methods of introducing the chemicals into pigments.
172E Armour Industrial Chemical Co.

Coagulation.....The chemistry of coagulation applied to effective water treatment in municipal and industrial plants; practical approaches and solutions discussed in brochure.
172F Nalco Chemical Co.

* From advertisement, this issue.

Disposable Filter.....Bulletin describes disposable filter catridges for filtering plating solutions, alcoholic beverages, diesel fuels and chemical process streams.
173A The Cuno Engineering Corp.

Epoxy Adhesive.....Data sheet describes new adhesive that manufacturer claims will withstand physical and chemical shock to a greater degree than all previous epoxy adhesives.
173B Isochem Resins Co.

Fatty Acids.....Booklet covers caprylic, capric, lauric and myristic acids, stripped and distilled coco acids and a capric-myristic blend with applications in many diverse products.
173C Armour Industrial Chemical Co.

Fiber Insulation....Specially processed mineral wood fiber insulation for cryogenic applications is described in information sheet that lists form, uses and advantages.
173D Johns-Manville Corp.

Flooring Compound.....Bulletin describes a new, easily applied, chemical and wear resistant flooring compound that, the manufacturer claims, is stronger than concrete.
173E Ralph V. Ru'on, Inc.

Fluorides.....Another new fluoride, silicon tetrafluoride has been introduced and proved successful. These fluorides are used in many industries for a variety of jobs.
167 *The Harshaw Chemical Co.

Graphite and Carbon Felts.....Information on eight grades of plain and reinforced graphite and carbon felts used in insulation, gas filtration and gasketing given in data sheet.
173F National Carbon Co.

Hexyl Alcohol.....Of special interest to vinyl plastic compounders are the phthalate esters of Hexyl Alcohol which exhibit high efficiency & good solvating properties.
57 *Enjay Chemical Co.

High-Temperature Alloys....Quick and ready reference to the comparative properties of company's complete line of high-temperature alloys is contained in 20-page booklet.
173G Haynes Stellite Co.

* From advertisement, this issue

Want to build up your files and keep them up-to-date? You can get any publication in this comprehensive guide — free — just for the asking.

It's easy—simply circle item's number on the Reader Service Postcard and mail. Replies will come directly from companies offering the literature.

ANNOUNCING . . .

The key to Thermophysical properties of over 14,000 substances

Virtually a desk-top digital computer, here is a comprehensive guide for engineers and scientists requiring information on thermophysical properties of substances.

The Retrieval Guide provides quick access to the world literature on seven thermophysical properties: thermal conductivity, thermal diffusivity, diffusion coefficient, specific heat, viscosity, emissivity, and Prandtl number. Properties of 14,240 substances are reported, and 10,000 scientific and technical papers are cited. Each paper is coded for its actual content — substance, property, physical state, subject, language, and other data—assuring a positive knowledge as to what it contains.

Just Published

RETRIEVAL GUIDE TO THERMOPHYSICAL PROPERTIES RESEARCH LITERATURE

SIGNIFICANT DATA

14,240 substances reported
—elements and chemical compounds: 3,600 substances
—ferrous alloys: 1,100
—nonferrous alloys: 2,530
—mixtures and solutions: 5,750
—commercial products: 1,260 materials

37,800 reference entries
—thermal conductivity: 9,000
—specific heat: 8,500
—viscosity: 13,750
—emissivity: 850
—diffusion coefficient: 5,200
—thermal diffusivity: 350
—Prandtl number: 150

10,000 references covering world literature
—1,210 journals, reports, and books supplying the references

9,439 contributing authors conveniently indexed

1,892 pages, large 8½ x 11 format

Edited by Y. S. TOULOUKIAN

Director, Thermophysical Properties Research Center, Purdue University

Representing the printout of a special computer program, the guide provides authoritative *source information*—access to a massive body of knowledge that has been collected, analyzed, and correlated to meet the pressing needs of science and industry. Conveniently arranged in three volumes, which are used jointly, the Retrieval Guide is organized as follows:

I: A comprehensive guide to substance classification, a dictionary of synonyms and trade names listed in the volume, and a classified formula and name index covering 14,240 substances.
II: Contains 37,800 classified code entries covering the seven properties.
III: Provides 10,000 bibliographical citations, and an index of 9,439 names of contributing authors.

The sources cited include scientific and technical journals, reports of industrial organizations and research centers, and others.

SEND FOR FREE INFORMATION BOOKLET

McGRAW-HILL BOOK COMPANY, INC., Dept. CE-1-9
327 West 41st Street, New York 36, N. Y.

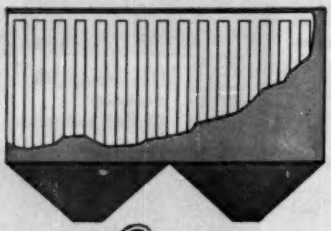
Please send me without obligation additional information on the RETRIEVAL GUIDE TO THERMOPHYSICAL PROPERTIES RESEARCH LITERATURE. (No salesman will call).

Name .....
Company .....
Address .....
City ..... Zone ..... State .....

CE-1-9

SINCE 1874 SLY

SLY DUST FILTERS For FULL-TIME OPERATION

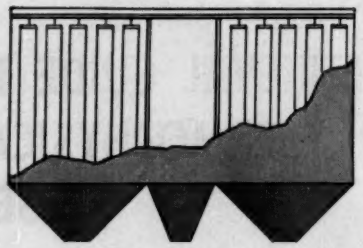


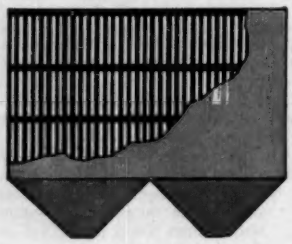
1900's SLY INTERMITTENT DUST ARRESTER

Required complete shut-down periodically for filter bag cleaning.

1930's SLY AUTOMATIC CONTINUOUS TUBE-TYPE FILTER

Sections had to be shut-down alternately for cleaning. Varying suction resulted in incomplete collection.





TODAY NEW SLY "ROLL-CLEAN" DYNACLONE®

Provides uniform suction at dust sources to collect all the dust.

Continuous Dust Suppression Through Constant Suction

The Dynaclone operates continuously, 24 hours a day if required. There is no fluctuation in air volume. This means complete dust collection.

The Dynaclone keeps itself clean automatically. Resilient rubber rolls form a positive seal as each row of bags is cleaned by atmospheric air. A single exhaust fan provides *both* suction for dust collection and air for cleaning. No auxiliary blowers required.

The Dynaclone provides 20 to 40% more cloth in a given space than any other dust filter. Space saved means lower installation costs, simplified piping and ductwork.

New "Resist-O-Wear" filter bags offer 2 to 3 times more bag life. And any bag can be changed without disturbing any other.

More than 40,000 Sly Dust Filters in operation, including over 1,000 Dynaclones. Get complete details . . .

SEND FOR 36-PAGE CATALOG 104

THE W. W. SLY MANUFACTURING CO.

4771 Train Avenue • Cleveland 1, Ohio • Offices in Principal Cities • Overseas Licensee: Andrew Air Conditioning Ltd., London S. W. 1, England

LITERATURE . . .

Metal Finishing.....16-page technical instruction bulletin describes company's nickel sulfamate process for metal resizing, electroplating, electroforming etc.
174A Hanson-Van Winkle-Munning Co.

Morpholine.....A new booklet, "Performance of Morpholine in Floor Polish-Rate of Development of Water Resistance" tells of the many advantages of this product.
129b *Union Carbide Chem. Co.

Neutralizing Amines....Simple method to maintain an alkaline pH in steam and condensate systems by using organic compounds for corrosion control is explained in bulletin.
174B Ionac Chemical Co.

Nitriding Processes.....Bulletin covers the case hardening of metals with anhydrous ammonia atmospheres in various nitriding applications. Includes brief history.
174C Armour Industrial Chemical Co.

Organic Solvents.....64-page booklet of chemical properties, formulae and other information "Organic Solvents and Chemicals" gives information on 150 products.
174D Chemical Solvents, Inc.

Phosphorescent Compounds....16-page bibliography lists over two-hundred compounds as a guide to identifying solutions through their phosphorescent properties.
174E American Instrument Co. Inc.

Plastics.....20-page booklet briefly describes many general-purpose resins latices and compounds and discusses present uses as well as suggestions for new uses.
174F B. F. Goodrich Co.

Plastic Fabrications.....Determining advantages of branch and linear polyethylene or polyproplene in selecting most economical fabrications process discussed in house organ.
174G American Agile Corp.

Polyethylene.....Results of tests on polyethylene formulations with a high resistance to sunlight and outdoor weathering are described in Bulletin No. 5.
174H Eastman Chemical Co.

Polyethylene.....Bulletin gives properties and uses of high-density Tenite polyethylene, a linear polymer with high stiffness, tensile strength and hardness.
174I Eastman Chemical Products

Polyethylene Resins.....A pressure technique for the rapid emulsification of three low molecular weight resins is described in technical data report.
174J Eastman Chemical Products Inc.

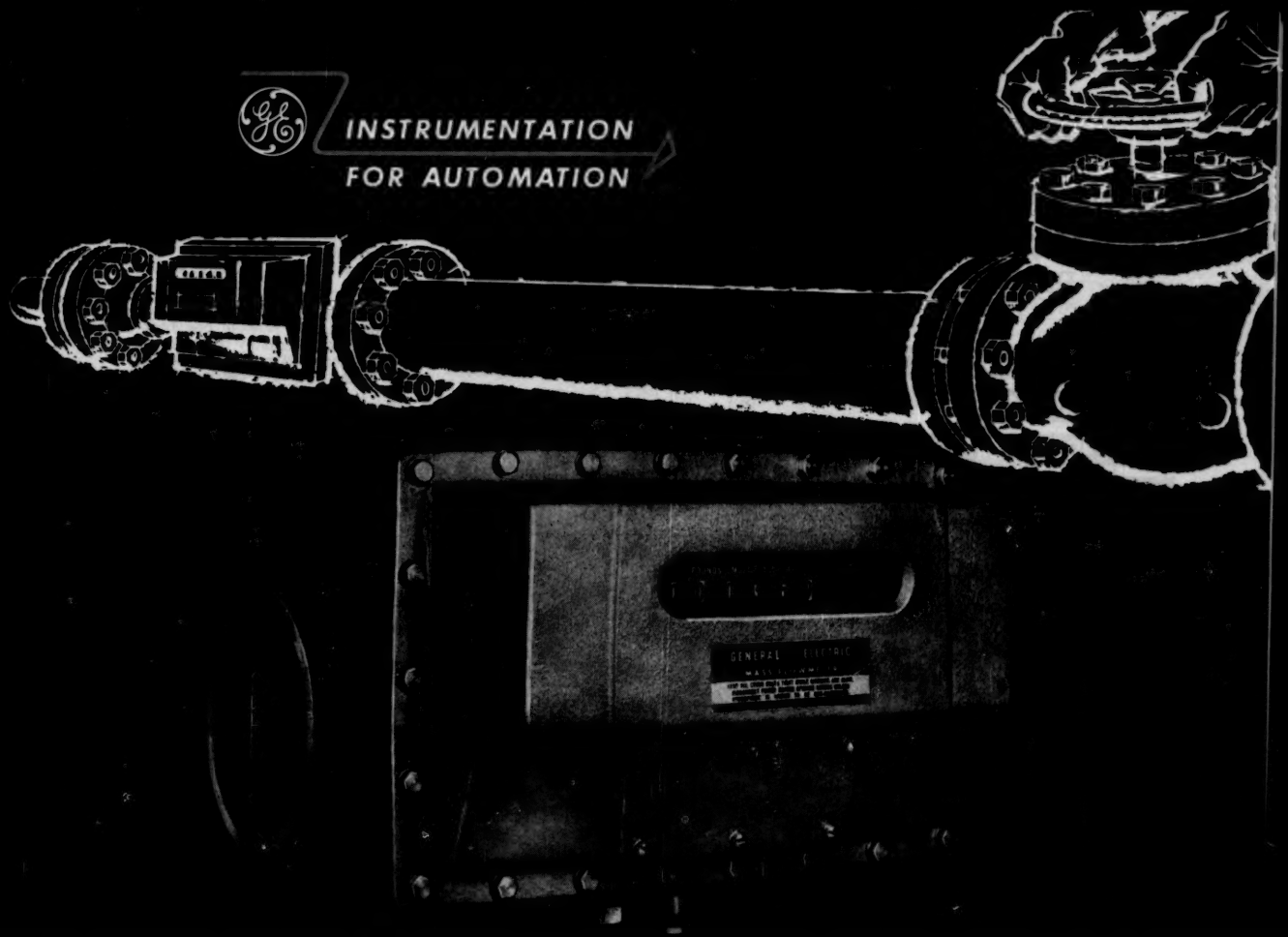
Polymers.....Brochure includes information on the instability of plastics in the presence of light and oxygen and describes a new stabilizer for these affects.
174K Guardian Chemical Corp.

Protective Coatings.....The solution to a wide variety of corrosion and deterioration problems is presented in an 8-page bulletin on bitumastic cold-applied protective coatings.
174L Kopper Co., Inc.

Resin Molding.....Descriptive booklet of the properties, uses, and molding requirements of compounds based on Dapon® diallyl phtalate resin is a handy guide.
174M Food Machinery & Chemical Corp.

* From advertisement, this issue

INSTRUMENTATION
FOR AUTOMATION



Now, with 12 standard ranges, General Electric Mass Flowmeter

PERFORMANCE-PROVED

. . . ON THE LINE! Today, many companies in the petroleum, chemical, petrochemical and natural gas industries are accurately measuring valuable process fluids directly in pounds with the General Electric True-Mass Flowmeter.

For example, these 12 applications have been performance-proved in actual service metering:

- **air • natural gas • alcohol • vinyl chloride**
- **freon • ammonia • liquid carbon dioxide**
- **ethylene • liquid petroleum gas • naphtha**
- **jet fuel • methane hydrogen mixtures**

(*Many more to come—let us know what your specific application is.*)

NEW ACCESSORIES FOR APPLICATION FLEXIBILITY:

Now, you can control batch blending accurately on a system basis with this flowmeter and new accessories which include:
counters—permit remote digital readout; **pre-set counters**—for automatic blending; **ticket and tape printers**—allow permanent and remote recording of flow.

AND *ALL* MODELS FEATURE:

- Accuracy independent of variations in density, pressure, viscosity and temperature
- Completely self-contained, self-integrating unit
- Low pressure drop
- Accuracy unaffected by fluctuation in power supply voltage and frequency
- Long-term stability for minimum maintenance and infrequent field calibration
- Quick response to rapid changes in flow without overshoot or lag
- Measurement in pounds—eliminates tedious conversions

DO YOU HAVE AN APPLICATION for this revolutionary new instrument? Chances are you do, and we'd like to know about it. Contact your nearby G-E Sales Office, or write directly to General Electric Co., Section 599-03, Schenectady 5, N. Y. Be sure to ask for bulletin GEA-6925A. In Canada, contact Canadian General Electric Co., 940 Lansdowne Avenue, Toronto 4, Ontario. On applications in the natural gas industry, contact Black Sivalls and Bryson, Inc., P.O. Box 1714, Oklahoma City, Okla.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

In Which of These Industries or Processes can NALCO 680 SODIUM ALUMINATE ($Na_2Al_2O_4$) Be Put to Work?

CHEMICAL PRODUCTION
LION TAMING
DETERGENT MANUFACTURE
GLASS and CERAMICS
PAINTS and PIGMENTS
CEMENT and MORTAR
PHARMACEUTICALS
PULP and PAPER MAKING
RUBBER
BASKETWEAVING
TEXTILES
WATER TREATMENT

As far as we know, only lion tamers and basketweavers don't use much Nalco 680 sodium aluminate. All the other industries listed do. So do many others. Nalco 680, a low-cost source of high purity alumina, offers many advantages as a chemical intermediate, including:

High alumina content—average 46% Al_2O_3.

Excellent stability—careful production processes, plus special stabilizers, maintain high stability while retaining an optimum Na_2O/Al_2O_3 molecular ratio of 1.15/1.

Purity—iron content is approximately .01 per cent; silicon, .02 per cent; and only trace levels of calcium, magnesium, and tin.

Low corrosivity—Nalco 680 sodium aluminate solutions are alkaline, making stainless steel or rubber/plastic/lead lined equipment unnecessary. Also, when Nalco 680 is used with alum to produce alumina, NaOH from the sodium aluminate reduces alum-produced sulfuric acid.

Multiplicity of uses—Nalco 680 is a chemical intermediate of many uses. Some of the many compounds which can be made from 680 are: aluminum stearate, aluminum acetate, free alumina, acid alumina sols, aluminum hydroxide, paint gels, aluminum hydrates, and aluminosilicate zeolites.

Handling/shipping ease—Nalco 680 is easily and rapidly dissolved in water. Its high concentration means that less 680 is needed per process, saving warehouse space and reducing shipping expense.

The foregoing is only a brief description of the uses and advantages of Nalco 680 sodium aluminate. For complete information write for a copy of Nalco Bulletin K4. Or, call your local Nalco field representative. Even if you weave baskets or tame lions, you may find a use for Nalco 680—researchers are finding so many new uses for it that we'd be reluctant to say definitely that there's *any* industry or process in which it can't be used in some way.

NALCO CHEMICAL COMPANY
6236 West 66th Place Chicago 38, Illinois
Subsidiaries in England, Italy, Mexico, Spain, Venezuela, and West Germany Germany
In Canada—Alchem Limited, Burlington, Ontario
... Serving Industry through Practical Applied Science

Nalco CHEMICALS

LITERATURE . . .

Resins.....Two technical reports, "Resin Forming Reactions of Epoxide 201" & "High Temperature Epoxy Resins" plus tech. information sheets on Unox Epoxides 206 and 207.
129a *Union Carbide Chemical Co.

Silicone Coatings.....Publication gives description of various applications of silicone release coatings as well as the chemistry of these materials. Tables and charts included.
176A General Electric Co.

Silicones.....New descriptive brochure, "Why Silicone-Based Paints Mean Less Maintenance" is available. Covers the new paints based on silicone resins.
59 *Dow Corning Corp.

Sodium Aluminate.....Nalco 680 offers high alumina content, excellent stability, purity, low corrosivity and multiplicity of uses. All details are in Bulletin K4.
176 *Nalco Chemical Company

Spherical Powders.....New process of producing spherical powders of metals and metal alloys ranging in size from 5 to 150 microns is described in 8-page technical bulletin.
176B Linde Co.

Starch Converting.....Information kit on dustless, high density, flash-dried starch for enzyme converting contains 3-page technical bulletin and 4-page brochure.
176C Corn Products Sales Co.

Teflon® Coatings.....Folder describes properties and successful applications for coating of metal and ceramic tools to contribute anti-sticking properties.
176D Cadillac Plastic & Chemical Co.

Testing Filter.....Micro-porous plastic material with uniform micron sized holes forms basis for a technique to identify the chemical composition of individual particles.
176E Gelman Instrument Co.

Thermoplastic.....Kynar resin . . . is a crystalline, high molecular weight polymer of vinylidene fluoride (CH_2-CF_2). It is now available in commercial quantities.
79 *Pennsalt Chemicals Corp.

Thiodipropionitrile.....Bulletin 106 describes compound that finds application as a plasricizer, softening agent, and a selective solvent. Available in commercial quantities.
176F Halby Products Co., Inc.

Thiodipropionate.....Antioxidant and preservative for edible materials, antioxidant for soap, stabilizer for polypropylene, and additive for lubricants described in Bulletin 101.
176G Halby Products Co. Inc.

Urethane Foams.....The advantages of "Genetron" auxiliary blowing agents in the production of flexible urethane foams for comfort cushioning are featured in bulletin.
176H General Chemical Div.

Urethane Foam Catalyst.....Bulletin describes properties of a stabilized stannous octoate catalyst designed to minimize the loss of catalytic activity during exposure to air.
176I Witco Chemical Co.

Vat-Dyeing....120-page treatise on the latest vat-dyeing techniques for cellulosic fibers contains complete descriptions of techniques, formulations and methods.
176J General Dyestuff Co.

* From advertisement, this issue.

USED TO THINK EVERY STEAM TRAP LEAKED STEAM.

THEN I FOUND ONE THAT DIDN'T, BUT IT WOULDN'T VENT AIR.

FOUND ONE THAT VENTED AIR, BUT IT NEEDED A COOLING LEG.

DISCOVERED A TRAP THAT REMOVED CONDENSATE AT STEAM TEMP, -MAINTENANCE WAS TOO HIGH.

THEN I FOUND A LOW MAINTENANCE TRAP. IT DIDN'T WORK AGAINST BACK PRESSURE.

AT LAST I FOUND ONE THAT WORKED AGAINST BACK PRESSURE, BUT ITS CAPACITY RATING WASN'T DEPENDABLE.

ARMSTRONG PROMISES TRUE CAPACITIES AND EVERYTHING ELSE, SO I CALLED THEM. THEY TOLD ME TO RELAX. I COULDN'T.

THEY TOLD ME ABOUT ARMSTRONG'S GUARANTEE. WHAT'D I HAVE TO LOSE, I TRIED THEM.

EFFICENCY IS UP, FUEL BILLS ARE DOWN, SO ARE MAINTENANCE COSTS. MAN I'M LIVING!

No one trap can do *everything* better than every other trap. Some traps vent air better than others, some remove condensate faster, etc. But, there is no one trap *best* in every phase of trapping. Armstrong has been manufacturing the Inverted Bucket Trap for nearly fifty years, and though the traps have changed with the requirements of the times, the Inverted Bucket principle has remained. For on overall trap performance, year-in and year-out, nothing beats the Armstrong Inverted Bucket Trap. It's a rugged well-built trap that does *more* things better than any other trap. It's guaranteed because it's been proved.

For more details, see your Armstrong Representative and start living . . .

P. S. Like some good meaty reading? Ask for the 48-page Armstrong Steam Trap Book.

ARMSTRONG MACHINE WORKS
8589 MAPLE STREET
THREE RIVERS, MICHIGAN

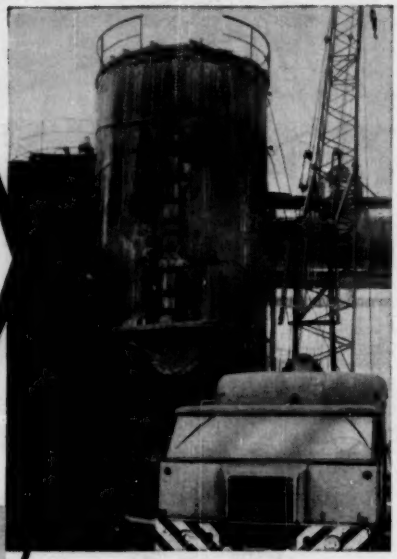
011-ST

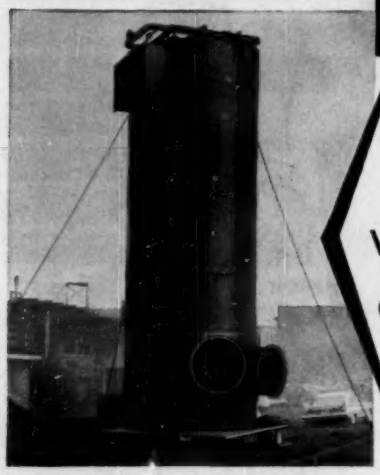
WHEN

CORROSION

TAKES ITS

TOLL





REPLACE

WITH

CONSTRUCTION

by

du Verre

New du Verre Reinforced Resin Bonded Fiberglass scrubbing tower being installed at a large metal refining plant to replace the badly corroded steel unit shown in the upper photo.

Where corrosion becomes prohibitively expensive — in high replacement costs, costly production downtime or contaminated product — it's time to investigate du Verre.

Tanks, ducts, hoods, stacks and other process equipment fabricated by du Verre of reinforced Resin Bonded Fiberglass, exhibit excellent resistance to both corrosion and erosion. They are many times lighter than steel, thus reducing freight, erection and supporting steel costs. du Verre has a smooth surface that improves flow characteristics and minimizes build-up of solids on interior surfaces.

Not a coating or lining, du Verre is a completely homogenous reinforced lamination — uniformly corrosion-resistant inside and out. It can be fabricated to your special shape, size and process requirements.

Write today for Bulletin No. 101 and see how du Verre fabrications could be sparing you the high costs of corrosion.

du Verre inc.

First in Quality for Complete Corrosion Control with Reinforced Plastics

BOX 37-A • ARCADE, NEW YORK

PLANTS IN ARCADE, NEW YORK • ATLANTIC BEACH, FLORIDA

LITERATURE . . .

Construction Materials

Fabrication.....Corrosion problems solved through resin bonded fiberglass construction. Process equipment such as ducts, stacks, hoods, etc. Facts in Bul. 101.
178 *du Verre Inc.

Fused Quartz.....Assures absolute chemical purity, extreme heat resistance, chemical inertness, etc. Many standard shapes and sizes available. Illustrated catalog.
L185 *Thermal American Fused Quartz Co.

Packing.....Homogeneous Compressed Asbestos Sheet Packing is available in 8 different gauges. Full information about the all-purpose gasket material in Bul. CE-11.
148 *Durable Mfg. Co.

Packings.....Chempro Styles 101 and 201 Teflon Shaft Packings are ideal on either centrifugal or reciprocating pumps. Further information in Bul. CP552.
168 *Chemical & Power Products, Inc.

Packings.....A new 32 page engineering manual gives helpful data on how to select and install proper support plates, distributors and hold-down plates.
32 *U. S. Stoneware

Pipe Insulation.....Glass fiber pipe outperforms all others. Has high thermal efficiency, easy & fast to install and comes in a variety of sizes. Complete information.
135 *Gustin-Bacon Mfg. Co.

Protective Coatings.....for steel tank linings, concrete floors, tank cars, etc. Selection of coatings & other Plastic Products covered in booklet.
190 *Wisconsin Protective Coating Co.

Steel.....A booklet entitled "Designing and Fabricating Structures of USS 'T-1' Steel" is now available describing the many ideal uses for this constructional alloy steel.
20-21 *U. S. Steel Corp.

Steel Floor Plates.....Booklet describes safety and economy features and illustrates applications. Includes safe uniform load tables, types available and specifications.
178A Eastern Stainless Steel Corp.

Tank Linings.....Copies of "The ABC's of Penton for Corrosion Resistance," and the Buyer's Guide which includes a complete listing of Penton tank liners, etc. are offered.
16-17 *Hercules Powder Co.

Wire Cloth.....For corrosive service, cloth with accurate mesh count, close tolerance wire diameter, precision weaving, etc. Bulletin F-C has details.
160 *Newark Wire Cloth Co.

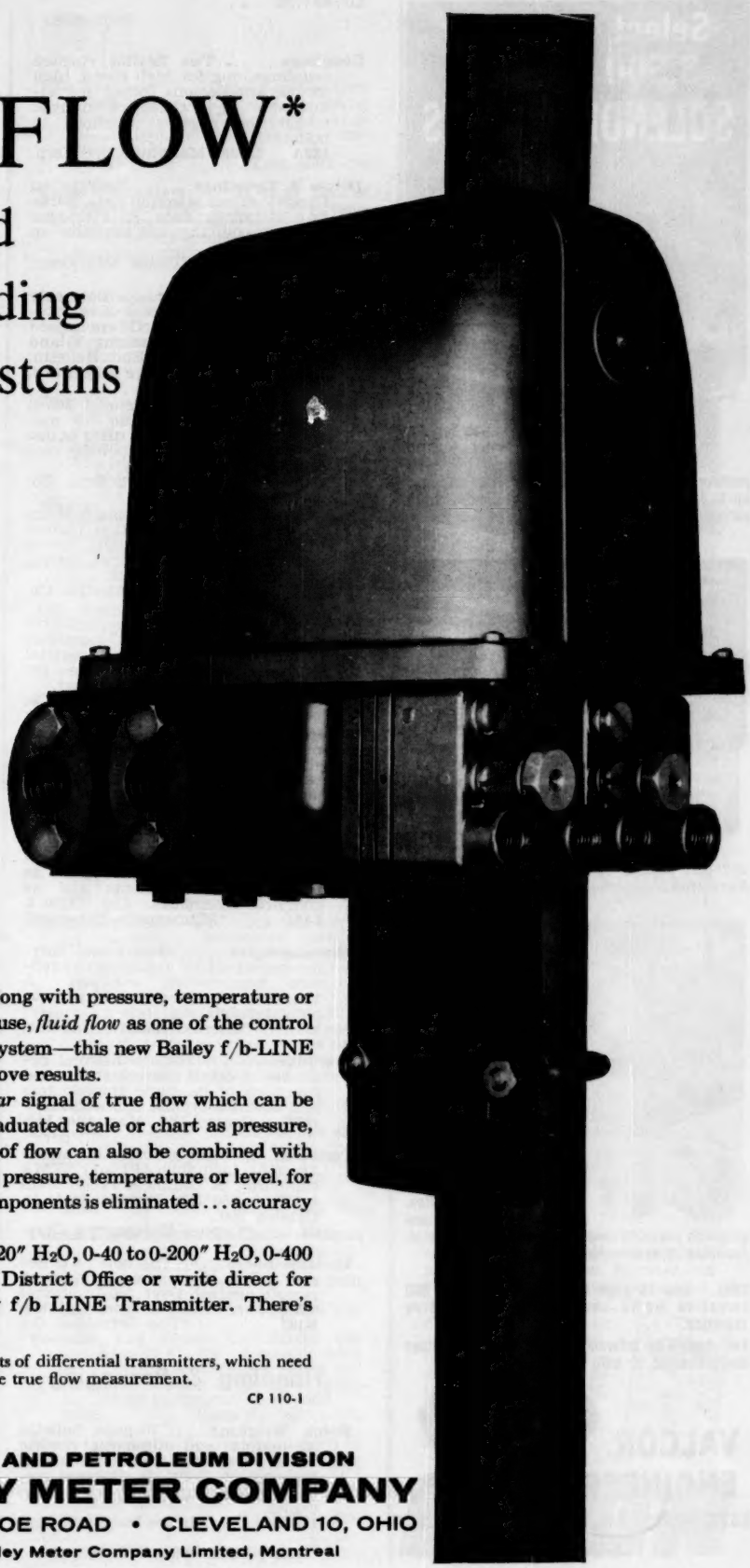
Electrical & Mechanical

Casters & Wheels.....All types of rubber treads—soft, medium & hard, for all kinds of floors. Featuring Neoprene rubber treads. New Manual describes nearly 4,000 types.
R184 *Darnell Corp., Ltd.

* From advertisement, this issue.

Measures TRUE FLOW*

to simplify and improve recording and control systems



If you intend to record *fluid flow* along with pressure, temperature or level—or if you now use, or plan to use, *fluid flow* as one of the control factors in a multi-element control system—this new Bailey f/b-LINE Transmitter can simplify and improve results.

It measures and transmits a *linear* signal of true flow which can be recorded on the same uniformly graduated scale or chart as pressure, temperature and level. This signal of flow can also be combined with other linear signals such as those of pressure, temperature or level, for improved control. Need for extra components is eliminated . . . accuracy of flow reading is increased.

Wide selection of ranges: 0-4 to 0-20″ H_2O, 0-40 to 0-200″ H_2O, 0-400 to 0-2000″ H_2O. Call your Bailey District Office or write direct for complete data on the new Bailey f/b LINE Transmitter. There's nothing like it.

*As opposed to pressure-drop measurements of differential transmitters, which need external square root extractors to produce true flow measurement.

CP 110-1

BAILEY METERS

CHEMICAL AND PETROLEUM DIVISION
BAILEY METER COMPANY
1054 IVANHOE ROAD • CLEVELAND 10, OHIO
In Canada—Bailey Meter Company Limited, Montreal

Select from over 3,500 different
SOLENOID VALVES from
VALCOR

Series SV-54 (3 way-4 way) general purpose solenoid valves for air, oil and water. Rugged construction, yet inexpensive. Multi-million cycle life. Pressure ratings up to 150 psi. Nylon seat outlasts steel. Infinite varieties available... lists as low as $10.75.

Series SV-61 (2 way) Nylon body valve is ideal for general purpose and OEM installations where millions of operating cycles are vital. Nylon seat and port threads outlast steel, yet cost less. Non-corrosive, shock-resistant, proof-pressure.

Series SV-5100 Specifically designed to handle the most corrosive media in industry. Manufactured in Teflon, PVC and Nylon varieties. Diaphragm construction prevents media contact with any metal. Available in direct-acting or piloted models.

FREE... new 16 page brochure — lists over 500 corrosive media — coded for correct valve selection.

For complete information on these or other models, write or call:

VALCOR ENGINEERING CORP.
VALCOR SOLENOID VALVES
5372 Carnegie Ave., Kenilworth, New Jersey
CHestnut 5-1665

LITERATURE . . .

Couplings.....Two flexible cushion couplings, one for high speed, high torque applications, other for attachment to flywheels of internal combustion engines described in bulletin.
180A Dodge Manufacturing Corp.

Drives & Couplings.....Bulletin on Dyna-V drives selection data, paraflex couplings data & Flexidyne drives & couplings are available on request.
165 *Dodge Mfg. Corp.

Drives, Screw Conveyor.....new ease of installation, new ease of maintenance, new economy. Offers rugged Reducer, external Packing Gland and optional Trough End. Bulletin.
164 *Dodge Mfg. Corp.

Gas Turbine.....New model 305-S single shaft gas turbine for mechanical and generator drive is described in bulletin 186. Includes discussion of applications.
180B Clark Bros. Co.

Induction Motors.....12-page bulletin on squirrel cage induction motors of basic dripproof designs covers performance characteristics, design, construction, ratings, etc.
180C Gentury Electric Co.

Industrial Power Systems.....'Better Power for Production" outlines principles of planning industrial power distribution systems for safety, reliability and economy.
180D General Electric Co.

Rotary Actuators.....16-page catalog describes family of five different size rotary actuators with torque range from 1500 to 702,000 inch pounds at 3000 psi.
180E Houdaille Industries, Inc.

Thermocouples.....a new line of hard-pack, small-diameter, mineral-insulated thermocouples. Available as bulk material, elements and as complete assemblies. Cat. G100-4.
L181 *Minneapolis-Honeywell

Thermocouples.....Base metal thermocouples gives consistently reliable temperature readings. A Thermocouple Catalog E-4 has complete information.
154 *Thermo Electric Co., Inc.

Transductors.....38-page manual describes in detail characteristics and functions of its static transductors and outlines typical applications.
180F Control Div., Magnetics Inc.

Turbines.....Built to customers' specifications, including API and NEMA standards. A complete range from 1 HP to 250 HP. Further facts in Catalog 200.
53 *Coppus Engineering Corp.

Variable Speed.....The new "400 Series" offers lever, screw, vernier or remote control. Over 250 fractional horsepower models & types. Catalog.
B187 *The Zero-Max Co.

Handling & Packaging

Batch Weighing.....20-page bulletin on manual and automatic electric batch weighing systems contains information about six different systems. Diagrams and photos included.
180G Gilmore Industries Inc.

* From advertisement, this issue

Take Guesswork Out of Lab Crushing & Grinding

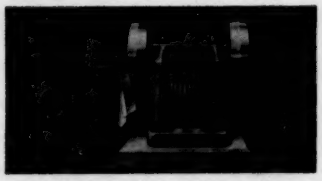
Sturtevant Design Provides Easy Access for Cleanouts — Returns Complete Sample

In seconds, because of "Open-Door" accessibility, all Sturtevant crushing or grinding parts are exposed for thorough cleanouts. 100% sample return is easy to secure.

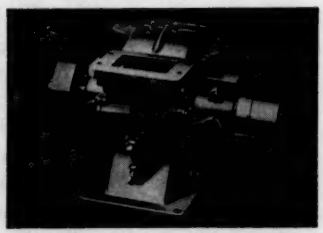
Sturtevant laboratory machines are ruggedly constructed — design, based on production models, gives top lab or pilot performance.

Send for Bulletin No.067, which gives full description of all Sturtevant laboratory machines.

Lab Crushing Rolls: Special lab design. Two models: 8 x 5 in. and 12 x 12 in. rolls. Capacities to 10 tph. Both models adjust down to 20 mesh. Tires of high carbon forgings. Automatic feeder, adjustable controls.



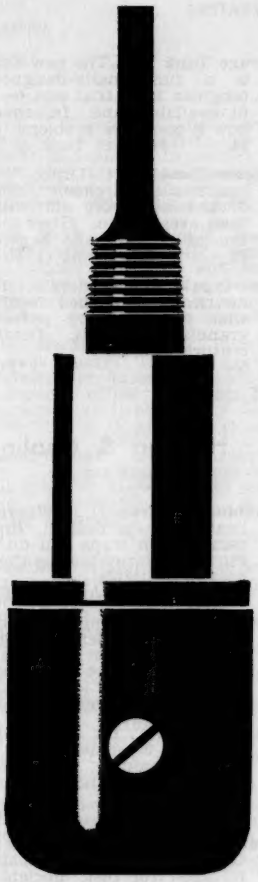
Lab Jaw Crusher: Crushes hardest rocks at ½ to ⅛ in. settings. Roll jaw action — no clogging. Feed opening 2 x 6 in. Capacity to 1900 lbs. per hr. at ½ in. setting. Instant adjustment. Manganese jaws, reversible shield.



Lab Swing-Sledge Mill: 5 x 6 in. opening takes soft, medium, tough or fibrous feed. Capacity to 1 tph. Fines regulate from 1 in. to 20 mesh. Choice of gratings, hammers (or knives).

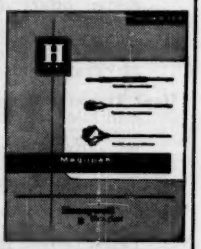
Sample Grinder: Disc type grinders for dry, friable soft or medium materials. Three sizes — 6 in., 10 in., and 14 in. take feed as coarse as ¼ in. Produces 100 mesh fines at capacities to 200 lbs. per hr. on largest model. Regulate 10 to 100 mesh. In-operation adjustment.

STURTEVANT MILL COMPANY
100 Clayton St., Boston 22, Mass.



MegopaK
THERMOCOUPLES

Honeywell's new line of hard-pack, small-diameter, mineral-insulated thermocouples. Available as bulk material (combination of wires, insulation and sheath); elements (with measuring junction); and as complete assemblies (with terminations and mounting attachments). From this one dependable source come thousands of other accessories to make your instruments perform at their very best.



Get details from your Honeywell field engineer, or write today for Catalog G100-4.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell
First in Control
SINCE 1888

LITERATURE . . .

Belt Conveyor.....Conveyors for both small and large tonnages, for routes of any length. Offer a broad range of pulleys, drives terminal machinery, etc.
14-15b *Link-Belt Co.

Bucket Elevators.....22-page booklet contains engineering data on various types of bucket elevators and recommends grades of belting for elevating different materials.
181A Hewitt-Robins Inc.

Bucket Elevators.....Unlimited solutions to vertical or inclined movement of a wide variety of materials. Fourteen types in four basic designs are offered.
14-15e *Link-Belt Co.

Bulk-Flo System.....One unit combines a feeder, elevator and conveyor. Operates horizontally, inclined or vertically. A catalog is offered.
14-15c *Link-Belt Co.

Feeders.....are suspended from the feed bin which eliminates costly feeder support structure, provides accessibility to equip. & requires low head room. Bul. 33-E-11.
140 *Hardinge Co.

Lift Trucks.....8-page brochure describes four low-lift, platform model, battery powered hand trucks designed for fast horizontal movement of palletized materials.
181B Clark Equipment Co.

Lift Trucks.....The place of heavy duty industrial lift trucks in industry is pictorially described in a 12-page booklet that is the fourth in a series of facts and factors booklets.
181C Automatic Transportation Co.

Loading Arm.....Standard models are available in 3" or 4" sizes in either rigid or telescoping designs with flanged or threaded riser connections. Information.
203 *Continental-Emsco Co.

Oscillating Conveyors....All four types of oscillating conveyors provide surge-free movement of materials. Catalogs are available on request.
14-15d *Link-Belt Co.

Overhead Materials Handling.....Brochure describes carriers, cranes, tractors, track switches, grabs and electrification. Detailed studies of track design, peening and stresses given.
181D Cleveland Tramrail Div.

Packers.....6-page, illustrated, file size bulletin describes continuous motion case packers. Units provide complete automation possible for bottle, can or jar packing.
181E Geo. J. Meyer Mfg. Co.

Pneumatic Materials Handling Systems.....The range of equipment offers the best single source for solving problems in moving dry bulk materials pneumatically. Lit.
55a *Fuller Co.

Portable Bag Closer.....Model CR weighs only 9½ lbs. Available with or without Faseal tape binding attachment. Details & complete catalog file of equipment on request.
B182 *Dave Fischbein Co.

Screw Conveyors.....Easily adapted to congested locations. Operate horizontally, vertically or inclined. Offers optional Quik-Link feature. Catalog available.
14-15a *Link-Belt Co.

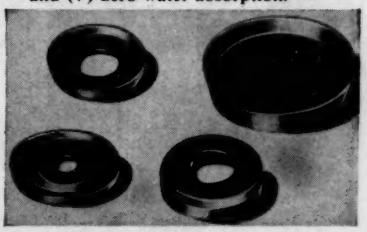
* From advertisement, this issue

RULON®
TEFLON

RULON — first practical fluorocarbon for cup packings

Dixon's new post-forming technique makes use of Rulon's plastic memory to insure tight seals under all conditions . . . at lower cost than ever before!

Packings of Rulon (filled TFE) give you: (1) low friction, (2) high resistance to wear, (3) low deformation under load (½ that of Teflon*), (4) wide temperature tolerance (−400° to +500°F), (5) chemical inertness, (6) lube free operation, and (7) zero water absorption.



RULON now serves in pumps, valves, motors, compressors and scores of other products manufactured by leading companies across the nation. Dixon offers the widest variety of basic shapes, both in RULON and Teflon . . . plus engineering capability to formulate special reinforced fluorocarbons for special needs. Also, Dixon can supply molded, machined, stamped, cut or extruded parts to meet your print.

See our guide-book on RULON, Bulletin #9572, in Sweet's Product Design File or send details for recommendations. DIXON CORPORATION, BURNSIDE ST., BRISTOL, R. I.

* DuPont T.M.

DIXON

permanent magnetic force...

A sleeve, raised and lowered within a nonmagnetic tube, attracts or releases an Alnico magnet attached to the mercury (or dry contact) switch. Basically, this is Magnetrol.

The operating principle behind MAGNETROL LIQUID LEVEL CONTROL

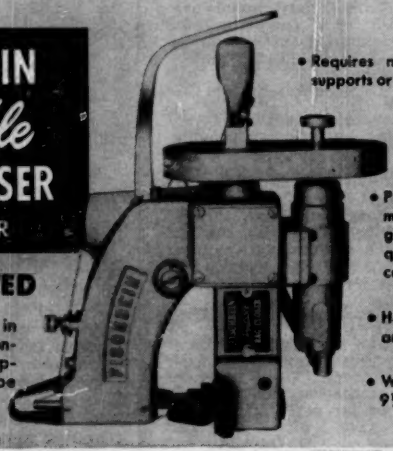
Because its operating principle, based on the proper use of a permanent magnet, guarantees a perpetual guardianship over your critical liquid levels, the Magnetrol liquid level control unobtrusively takes the most important place in any system or process where it is necessary to keep a liquid at a constant level. Principle and action are so simple that failure is virtually impossible. Magnetrol is versatile, too—will handle almost ANY liquid, at ANY temperature, at ANY pressure, with the same precision and dependability. No mechanical or electrical linkages to stick, bind, ride out of line or wear out. Available for controlling level changes from ½" to 150 ft. Multi-stage switching when desired. Write to

MAGNETROL, Inc., 5324 Belmont Road, Downers Grove, Ill.

FISCHBEIN Portable BAG CLOSER
MODEL CR

AIR OPERATED

Recommended for use in areas where explosion-proof electrical equipment would normally be required.



- Requires no installation, supports or plant space . .
- Power transmitted by fibre gears that require no lubrication.
- Handles textile and paper bags.
- Weighs only 9½ lbs.

Available with or without FISCHBEIN FASEAL®

Tape Binding Attachment

Produces perfect tape-bound closures. Complete portability maintained. Attachment can be quickly removed when tape binding is not required.

For details and complete catalog file of Fischbein Bag Closing Equipment . . . write. . .

DAVE FISCHBEIN CO.
2720 30th Ave. S., Dept. 3C, Mpls. 6, Minn.

LITERATURE . . .

Storage Tank.....The new Cylindroid is a functionally-designed, rectangular tank that can be built to fit available land. Information on how it can solve problems.
51 *Graver Tank & Mfg. Co.

Tractor-Shovel.....Latest "No-Spill" bucket assures cleaner, more productive and more efficient service than ever before. Gives many on-the-job savings and benefits.
31 *The Frank G. Hough Co.

Vane-type & Roll Feeders.....for volumetrically controlled feeding of a wide range of dry pulverized or granular materials. Detailed literature offered.
55c *Fuller Co.

Heating & Cooling

Combination Traps.....Wherever fast heating up is desired, Heat-Kwik combination traps will do the job. Further information on their many uses is available.
136c *The V. D. Anderson Company

Evaporator.....Complete information on this all stainless steel quadruple effect evaporator is now available. Designed to meet your specific requirements.
198b *Goslin Birmingham Mfg. Co.

Float Traps.....for air purifiers, gas purifiers, condensate flow meters, master trapping, false water line sewers, etc. Further information on request.
136e *The V. D. Anderson Co.

Grate Coolers....Horizontal & Inclined Grate Coolers are compact, easily installed for fast, efficient cooling of materials such as nodulized phosphate rock, pebble lime, etc.
55e *Fuller Co.

Heat Exchangers.....New manual describes how to install and maintain double pipe heat exchangers. Parts list and recommended spare parts inventory is included.
182A Brown Fintube Co.

Heat Exchangers.....featuring a special design with high alloy and multipass liquor flow. Complete information on these heat exchangers is available on request.
198e *Goslin-Birmingham Mfg. Co.

Heat Transfer....Exclusive Multi-Zone design offers optimum steam distribution. Serpentine styles are also available for cooling. A bulletin No. P61 is available.
28 *Tranter Mfg. Co., Platecoil Div.

Heat Transfer Equipment.....Such as multiple effect evaporators and crystallizers. Details are available on different types which promise most efficiency for every dollar.
69 *Chicago Bridge & Iron Co.

Heat Transfer Equipment.....Evaporators, Vacuum Rotary Dryers, Drum Dryers, Heat Exchangers, and Flakers custom designed to meet your requirements. Information.
198a *Goslin-Birmingham Mfg. Co.

Heater....Hi-Turbiant offers two broad fields of application; heating transfer fluids and direct firing. Illustrated bulletin HT-100 gives detailed data & shows typical systems.
73 *Western Precipitation

* From advertisement, this issue

Heaters.....Complete information concerning a Grid system for your plant is available in catalog #956 Grid Cast Iron Steam Heat Transfer Surface upon request.
142 *D. J. Murray Mfg. Co.

Heaters, Tank.....Bulletin describes three types, vertically mounted, horizontally mounted and immersion type heaters, and gives necessary specification data on each unit.
183A Brown Fintube Co.

Inverted Bucket Traps.....Super Silvertop Bucket Traps are recommended for autoclaves, bare pipe, calenders, coffee urns, etc. Information is available.
136b *The V. D. Anderson Company

Packaged Boilers.....Sizes through 600 hp . . . oil, gas and combination oil-gas firing . . . larger sizes in Springfield water-tube boilers. Booklet "How to Select a Boiler."
70 *Cleaver-Brooks Co.

Preheaters.....Humboldt suspension type preheaters for preheating dry, pulverized Portland cement raw materials with rotary kiln waste gases. Literature.
55d *Fuller Co.

Steam Traps....."How to Select Steam Traps" has been written to give you an unbiased opinion in answer to all your steam trap difficulties. Available on request.
136a *The V. D. Anderson Co.

Steam Traps.....The 48-page book gives complete information and details on steam traps. Also information on design, construction and operation of Inverted Bucket Trap.
177 *Armstrong Machine Works

Steam Traps.....Thermostatic steam traps operate on a true balanced vapor-pressure principle, they discharge air, condensates & other non-condensables. Cat. 400.
161 *W. H. Nicholson & Co.

Thermostatic Steam Traps.....Quik-Flex thermostatic steam traps are used where fast heating up or outside freeze-proof installations are required. Literature.
136d *The V. D. Anderson Co.

Instruments & Controls

Analog Computer.....The Pace TR-10 is an all transistorized desktop analog computer. Permits rapid evaluation of different design approaches. Bulletin AC 934-EA-41.
80 *Electronic Associates, Inc.

Control Panels.....Permit automatic, remote, one-man control of multiple operations. Easily-read panel permits visualizing flow of material to storage or from process bins.
55g *Fuller Co.

Controllers.....6-page catalog describes pneumatic pressure and temperature controllers that will handle pressures to 10,000 psi, and temperatures from —125F. to 1000F.
183B OPW-Jordan Corp.

Controls, Motor.....New Spacemaker is the first two-high, 2 to 5 kv control center and the first in its voltage class. Inspection & maintenance are simplified. Details.
145 *Allis-Chalmers

*From advertisement, this issue

NO LUBRICATION
NO CONTAMINATION
NO MAINTENANCE

SULZER
NON-LUBRICATED RINGLESS
PISTON COMPRESSOR
Assures Absolute
Contamination-Free Compression
Of Dry Or Moist Gases!

- Unique Ringless Piston And Frictionless Piston Rod Stuffing-Box Requires Little Or No Maintenance
- For Air, Oxygen, Hydrogen, Dry Chlorine And Other Industrial Gases
- Available For Capacities Up To 4000 cfm And Discharge Pressures Up To 650 psig
- Over 25 Years Of Manufacturing Experience In Ringless, Non-Lubricated Piston Compressors

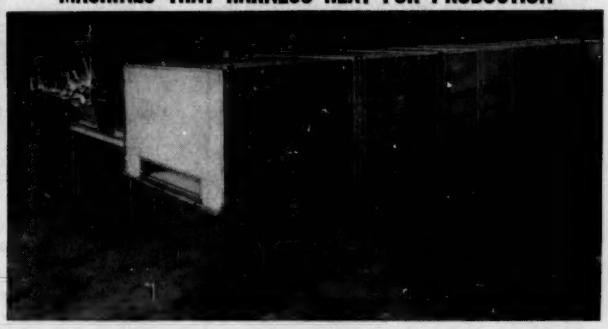
For further information, specifications, etc., contact:

SULZER

SULZER BROS. INC.
50 Church Street, New York 7, N. Y.

MACHINES THAT HARNESS HEAT FOR PRODUCTION

F FUSING
C CURING
D DRYING
F C



BLOWN VINYL FUSER-DRYER
Featuring a NEW Method Of Air Contact

DAWSON Units are increasing production efficiency for more and more companies all over the nation in fusing, curing, and drying operations. These units cut production costs, do the required job with maximum safety, speed, and accuracy. DAWSON ENGINEERING will determine the size unit required to fit your production schedule best. Your chemists and engineers are welcome any time in our plant to supervise the tests on which our recommendations are made.

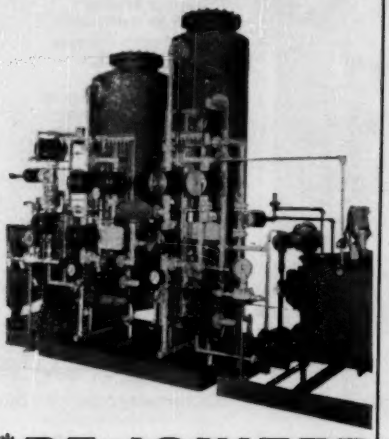
Write Now for Free Catalog

DAWSON *Engineering Company*
Canton, Massachusetts

AUTOMATIC DE-I*

ILLCO-WAY DESIGNERS AND BUILDERS

MODERN EQUIPMENT FOR ionXchange



*DE-IONIZER

Here is a typical *fully-automatic* De-Ionizer, skid-mounted, loaded with resins, tested, ready for hook-up in your plant. A complete Control Panel (not shown), built by IWT, is included. Valves are exclusive ILLCO-MATIC, high-density polyethylene, specially designed for ionXchange service, pneumatically-operated, and *proved* reliable in extensive use.

FOR ANY PROCESS REQUIREMENT, OR HIGH-PRESSURE BOILER MAKE-UP

Such De-Ionizers are used to provide extremely pure water, tailored to specifications for all kinds of processes, or to the particular conditions for make-up of modern high-pressure boilers.

TELL US YOUR NEEDS

Our pioneering experience, gained since the very beginning of ion-exchange, is available for the successful solution of your water-treatment problems. Call your IWT representative.

ILLINOIS WATER TREATMENT CO.
840 CEDAR ST., ROCKFORD, ILLINOIS
NEW YORK OFFICE: 141 E. 38th St., New York 17, N.Y.
CANADIAN DIST.: Pumps & Systems, Ltd., London, Can.

LITERATURE . . .

Electric Hydrometer.....16-page bulletin describes applications of instrument used in direct measurement of liquid density or to provide gravimetric correction.
184A The Liquidometer Corp.

Indicators.....Material-Level-Indicators signal audibly & visibly when materials reach a predetermined high or low level. Controls conveyor motors, valve circuits, etc.
55b *Fuller Co.

Liquid Level Control.....is available for controlling level changes from ⅛" to 150 ft. Multi-stage switching when desired. Information on Magnetrol on request.
T182 *Magnetrol, Inc.

Meter.....New Gyro-Integrating True Mass Flowmeter accurately measures flow of liquids, gases & liquefied-gases . . . directly in pounds. Bul. GEA-6925A, Section 599-03.
175 *General Electric Co.

Meters, Chemical.....For the volumetric measurement of corrosive liquids are covered in Bul. 46. Includes a chart of capacity groups, pistons and casing materials.
184B Buffalo Meter Co.

Pressure Indicators.....Newest additions to the standard line of differential pressure indicators are engineered for Lox, Filter & Fuel Systems. Bulletin 82-M-1.
184C Industrial Instrument Corp.

Pressure Systems....Button Diaphragm pressure systems are available in a variety of ranges giving accurate pressure measurement at high temps. Bulletin 98398 is offered.
24-25 *Taylor Instrument Co.

Recorder.....A brochure is available on request concerning a continuous vapor pressure recorder. It contains a general description of the instrument, illus., etc.
184D Hallikainen Instruments

Regulator-Flowmeter..... Engineering data on the 982 constant flow regulator is available. Includes materials of construction, specifications & operating instructions.
184E Hoke Inc.

Rotameter.....A new through-flow pneumatic transmitting rotameter is described in 6-page catalog. Mounting of 3-15 psig transmitter eliminates need for an extension.
184F Fischer & Porter Co.

Temperature Regulator.....This regulator knows how to handle the toughest assignments controlling liquids, air or gases. Designed for heating or cooling. Cat. A-AC.
149 *Robertshaw-Fulton Controls Co.

Transmitter.....This new f/b LINE transmitter simplifies and improves results. A linear signal of true flow is recorded on the same scale with pressure, temp. & level. Data.
179 *Bailey Meter Company

Pipe, Fittings, Valves

Couplings.....are available in brass, Malleable, Stainless, Aluminum, Monel, or other materials for corrosion resistance under any conditions. Illustrated Cat. C-11.
41 *Ever-Tite Coupling Co., Inc.

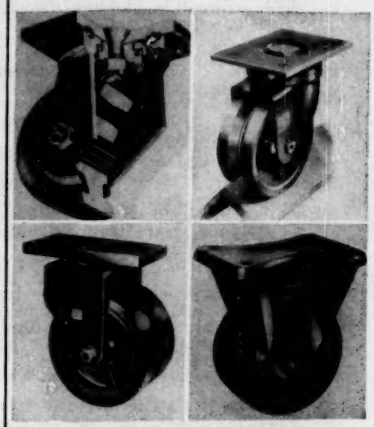
* From advertisement, this issue

Send for Your FREE COPY

New DARNELL MANUAL DESCRIBES Nearly 4000 TYPES of

DARNELL

CASTERS & WHEELS



the Ultimate in Performance

All types of rubber treads—soft, medium and hard—for smooth operation on all kinds of floors. Featuring Neoprene rubber treads - resistant to oxidation, oils and waxes as well as being unaffected by most chemicals - expertly compounded to Darnell standards.

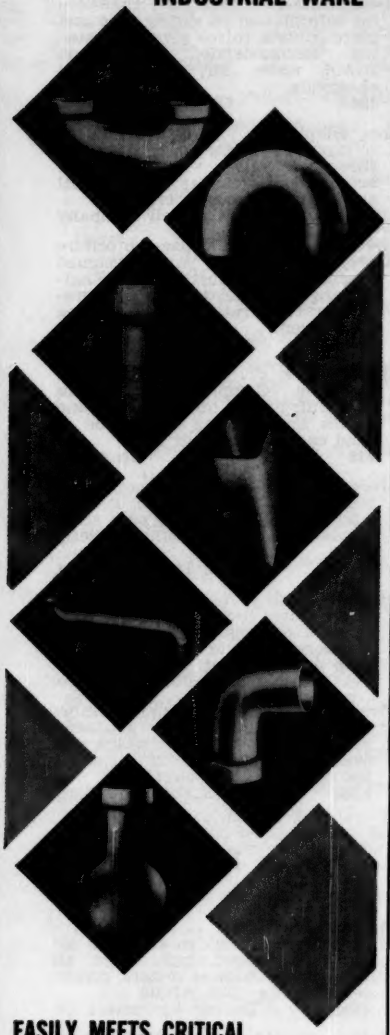
All casters, whether steel or rubber tread, available in swivel and stationary models with various top plates, stems and fittings for any type application.

Look in the YELLOW PAGES

DARNELL CORPORATION, LTD.
DOWNEY (Los Angeles County) CALIF.
37-28 SIXTY-FIRST, WOODSIDE 77, L.I., N.Y.
36 NORTH CLINTON ST., CHICAGO 6, ILL.
1000 PEACHTREE N. E., ATLANTA, GA.

VITREOSIL®

PURE FUSED QUARTZ INDUSTRIAL WARE



EASILY MEETS CRITICAL PRODUCTION REQUIREMENTS

- Absolute Chemical Purity
- Extreme Heat Resistance
- Thermal Shock Resistance
- Chemical Inertness
- Outstanding Electrical Properties
- Full Range Radiant Energy Transmission

Many standard shapes and sizes . . . and we fabricate for special needs. See our ad in **Chemical Engineering Catalog.**

Write for complete, illustrated catalog.

THERMAL AMERICAN FUSED QUARTZ CO., INC.
120 Salem St., Dover, N. J.

LITERATURE . . .

Flanges.....Catalog contains specifications for 150 lb. to 1500 lb. drop-forged steel flanges and welding neck flanges. Pipe size, hub diameter, size etc. included.
185A Harrisburg Steel Co.

Valve Pinch-Type.....Booklet discusses solenoid-operated valve suitable for metering, sampling and "on-off" control applications. Vacuum or pressure operation is possible.
185B RKL Controls, Inc.

Pipe.....Koroseal PVC pipe is unaffected by most alkalies, acids, salt, alcohol and oil. It does not react chemically, will not contaminate liquids. Booklet offered.
1 *B. F. Goodrich Ind. Products Co.

Pipe.....Yoloy Continuous Weld and Seamless Pipe offers resistance to atmospheric corrosion, soil corrosion, & to chemical corrosion. Details covered in new booklet.
185C Youngstown Sheet & Tube Co.

Piping Products.....Fluoroflex-T piping can handle the most difficult materials up to 500 F. They are resistant to most chemicals. Information.
61 *Resistoflex Corp.

Tubing.....Folder shows chemical analyses of standard carbon, alloy and stainless tubing steels used for corrosion resistant, or high temperature and/or pressure service.
185D Babcock & Wilcox Co.

Tubing.....Titanium and titanium alloy tubing are described in data memorandum No. 27. Applications include hydraulic and pneumatic lines and low-stress structural components.
185E Superior Tube Co.

Valves, Air Control.....Handy, quick-reference, specification catalog presents a new tested design of mechanically and manually operated air control valves.
185F Hoffman Valves, Inc.

Valve, Butterfly.....Features true close bearing fit for shaft; non-leaking, non-galling, corrosion-resistant. Bulletin 590X gives all the powerful facts.
R200 *W. S. Rockwell Co.

Valve, Packless.....The new Flexiphragm packless valve for unfiltered service traps impurities on seat and still closed tight. Further information on request.
185G George W. Dahl Co., Inc.

Valve Positioner.....Type 3560 is small & compact and offers split range. Features convenient adjustment and is easily reversible. Bulletin E-3560.
133 *Fisher Governor Co.

Valves.....The full capacity series 3-way valves are covered in Bulletin 91023. All types are illustrated and described in detail. Available on request.
185H Airmatic Valve, Inc.

Valves.....Forged Steel Gate and/or Globe Valves plus a complete line of gate, globe and angle valves in all standard materials: electric furnace iron, bronze, etc.
72 *R-P & C Valve Div.

Valves.....The new forged steel, inside screw, bolted bonnet gate and globe valves are available from stock in ¼" thru 2" sizes. Literature.
82 *Henry Vogt Machine Co.

* From advertisement, this issue

Handle Flammables SAFELY with Protectoseal PRODUCTS

STAINLESS DRUM FAUCETS

For 30 and 55 gal. drums. Self-positioning or rigid spouts. Self-closing. Stainless steel body. Teflon O-Ring Seal.

DRUM TRANSFER PUMP

For quick, safe dispensing from drums. Pumps up to 5 gpm. Optional cut-off control eliminates overflow, spillage. 3 built-in fire baffles protect drum contents from exterior ignition source.

OVAL SHAPE SAFETY CANS

Oval storage or dispensing cans save space. Available in stainless steel, terne plate or hot tin dipped. Safe, quick, filling or dispensing. Double wall fire baffles. Leather or Teflon gaskets.

FLAMMABLE STORAGE CABINET

Provides safe, convenient storage of flammable liquid safety cans at point of use. Removable, adjustable shelves. 45"x65"x18".

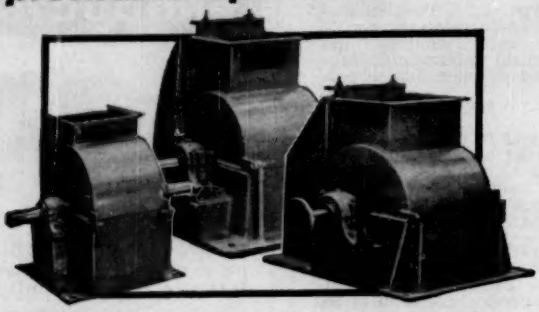
IN-LINE FLAME ARRESTER VENTS

Prevent flashbacks into tanks, process kettles etc. through vent opening. Complete, self-contained unit design simplifies inspection and maintenance. For 1", 2", 3" and 4" pipe. Write for Protectoseal Vent Catalog. Describes complete line of tank vents, fittings, accessories.

Write for the new Protectoseal RED BOOK. Contains flammables engineering fundamentals and complete line of safety containers and operating equipment.

THE PROTECTOSEAL COMPANY
115 S. WESTERN AVE. • CHICAGO 12, ILLINOIS

M & M chemical and plastic converters have many new features for smoother, more profitable operation



The exclusive design of small staggered and tapered cutting knives in the large cylinder gives the M & M Converter a slicing action instead of chopping or hammering . . . to relieve impact shock from bearings, shaft and basic construction. The large rotating cylinder mounted between heavy-duty roller bearings does not require any flywheel and the well-balanced design of the M & M all-welded steel construction assures trouble-free operation with the least amount of maintenance. These Converters are available in a variety of sizes. Shown are three models which are available with top or side intake and side or bottom discharge.

Write today for complete information.

MITTS & MERRILL

1007 SO. WATER ST. • SAGINAW, MICHIGAN

BUILDERS OF WORK-SAVING, MONEY-SAVING AND MATERIAL RECLAIMING MACHINERY SINCE 1854. 110

99% GUARANTEED REMOVAL

of Pipeline Process Contamination with Anderson Hi-eF Purifiers

Hi-eF Purifiers guarantee a high degree of entrainment removal in process gas, vapor, air or steam lines. Patented two-stage principle of separation with no moving parts results in low-cost, maintenance-free operation. Write for FREE SPECIFICATION MANUAL 803, containing data on 13 types of separators.

Hi-eF PURIFIER

By the Manufacturers of Super Silvertop Steam Traps

THE V.D. ANDERSON COMPANY

Division of International Basic Economy Corporation

1943 West 96th Street Cleveland 2, Ohio

LITERATURE . . .

Valves, Ball.....“Double-Seal” type serve throughout industry. High pressure “Double-Seal” type are at work in air & hydraulic systems. Brochure, “At Your Service”.
45 *Jamesbury Corp.

Valves, Control.....Complete engineering information on sliding gate and plate control valves given in catalog. Recommended for use on steam, water, air, oil, gas and chemicals.
186A OPW-Jordan Corp.

Valve, Diaphragm.....is available in a range of motor sizes from ½” through 6” valves. Wide choice of accessories such as: handwheel closing device, postioner, etc.
143 *Grinnell Company

Valves, Gate.....12-page brochure covers line of gate valves designed specifically for ductile iron. Engineering specifications, pressure-temperature ratings and testing data given.
186B The Ohio Injector Co.

Valves, Globe.....Catalog 60 is now available. Complete specifications on a full line of bronze valves and valves for handling every kind of fluid can be found in it.
119 *Crane Co.

Valves, Needle.....with the corrosion-resistance of 316 stainless steel in sizes from ⅛” to 1”, globe, angle & panel mounted patterns. Bulletin NV-3.
B188 *Marsh Instrument Co.

Valves, Pinch.....Massco - Grigsby pinch valves have patented “hinge” sleeve and patented Flex Seal ends. No working parts in contact with pulp or fluid. Cat. 609.
146 *Mine and Smelter Supply Co.

Valves, Solenoid.....Complete information on all models available. Also a 16-page brochure which lists over 500 corrosive media . . . coded for correct valve selection.
L180 *Valcor Engineering Corp.

Process Equipment

Agitators & Mixers.....Turbine-type propeller (to 120” in tanks to 50” dia.) slow speed, high speed, air lift, vertical turbine mixers, mixer-settler units. Bul. A2-B2.
139a *Denver Equipment Co.

Attrition Scrubbers.....High power input to efficiency remove sand coating, mix dense slurries. Rubber lined or acid-proof tanks. Sizes to 56” x 56”. Bul. A-8505.
139b *Denver Equipment Co.

Automatic De-Ionizer.....Complete, loaded, fully-instrumented, automatic ionXchange unit. Full particulars on this equipment is now available.
L184 *Illinois Water Treatment Co.

Centrifugals.....The Roberts LS/SC provides a combination of features. No metal to metal moving parts, rigid feed, wash, effluent, and solids-discharge connections.
157 *The Western States Machine Co.

Converters.....Chemical and plastic converters are available in a variety of sizes. Many new features for smoother operation. Complete information.
T186 *Mitts & Merrill

* From advertisement, this issue

LITERATURE . . .

Crushers.....Handbook prepared to aid users of Symons Cone Crushers in securing best possible performance and maximum efficiency includes information on common problems.
187A Nordberg Mfg. Co.

Crushing & Grinding.....Bulletin No. 067 gives a full description of all laboratory machines including Crushing Rolls, Jaw Crushers, Swing-Sledge Mill, & Sample Grinder.
R180 *Sturtevant Mill Co.

Dryer.....Interim Bulletin 1060C pertaining to the new Type MSX Externally Heated Molecu-Dryer contains applications and advantages plus illustrations.
187B C. I. Hayes, Inc.

Dryer.....Controlled dryness has been the answer to many problems caused by moisture. Details are available in Case History Sheets on how to solve many of these problems.
189 *Pittsburgh Lectrodryer Div.

Dryer Unit.....Rotary Gas Fired Dryer includes the drum, furnace, burner and instruments all assembled on base making an integral installation. Catalog.
T187 *Davenport Machine & Foundry

Dryer, Vacuum Rotary.....designed for efficient removal of moisture at low temperatures is described in detail in the booklet which is available on request.
198c *Goslin-Birmingham Mfg. Co.

Dryers, Drum.....are available with a variety of feed arrangements. Designed to meet your specific requirements. Further information on request.
198d *Goslin-Birmingham Mfg. Co.

Dust Filters.....The new "Roll-Clean" Dynaclone gives: continuous cleaning, constant suction & complete accessibility in the least possible space. Catalog 104.
174 *The W. W. Sly Mfg. Co.

Filter, Leaf.....Entire Roto-Jet filter operation can be antomated if desired. The cleaning operation requires only 6 to 8 gpm per jet, for 2 to 3 min. Illus. Cat.
L200 *Hercules Filter Corp.

Filters, Leaf.....The vertical leaf filter is available in vertical & horizontal tank types, in a wide range of leaf & tank sizes. New Bulletin 150 tells the story.
166b *T. Shriver & Company, Inc.

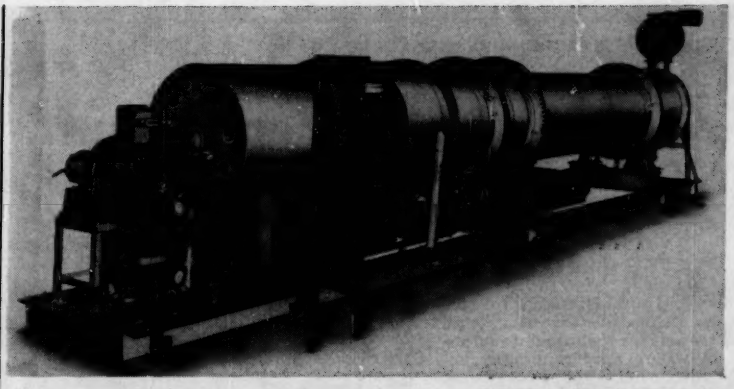
Filters, TiltingPan.....New bulletin contains valuable information on the use and economics of this special filter. Available now on request. Bul. F-2038A.
Cover *The Elmco Corp.

Filter Press.....for versatile and flexible operation, a wide range of pressure and a wide range of filter media. Catalog 59 gives complete details on designs, types & sizes.
166a *T. Shriver & Company, Inc.

Flakers.....with rapid and continuous operation. Diameter sizes from 18" to 60". Lengths to suit your specific requirements. Literature available.
198A *Goslin-Birmingham Mfg. Co.

Fluid Processes.....1961 "Fluidics" Buyers Guide, of interest to all processors of liquids or gases, gives well detailed information and concise engineering data.
187C Pfaudler Permutit Inc.

* From advertisement, this issue



A "DAVENPORT" 2'-6" x 16' Rotary Gas Fired Dryer

This compact dryer unit includes the drum, furnace, burner and instruments all assembled on base making an integral installation. Temperature entering this particular dryer is 750° F.

Let our engineers consult with you on your Pressing, Drying and Cooling problems or send for our catalog A. For quick reference consult your Chemical Engineering Catalog.

DAVENPORT MACHINE AND Foundry Company
A DIVISION OF MIDDLE STATES CORPORATION
Davenport, Iowa, U.S.A.

DAVENPORT
PRESSING — DRYING and COOLING Equipment
Continuous DeWatering Presses
ROTARY DRYERS Steam Tube, Hot Air and Direct Fire
Atmospheric DRUM DRYERS
ROTARY COOLERS Water and Air

New "400 SERIES"

ZERO-MAX

Stepless Variable Speed

Zero-Max "400 Series", a redesign of the complete line, gives you stepless variable speed control with a finger's touch. Over 250 fractional horsepower models and types (1/15 hp thru 3/4 hp) with or without motors, reverse or gearhead — output range from zero to 1200 rpm with 1800 rpm input. Zero-Max gives smooth, stable drive and constant torque from 2½ to 450 inch-pounds.

Change speeds instantly running or not. Truly stepless — zero to maximum. Lever, screw, vernier or remote control. Lever control provides fast yet precise control. Instant reverse and neutral.

Send for free catalog on the new Zero-Max "400 Series"

THE ZERO-MAX® COMPANY
Subsidiary of REVCO, INC.
2869 HARRIET AVE. SO., MINNEAPOLIS 8, MINN.

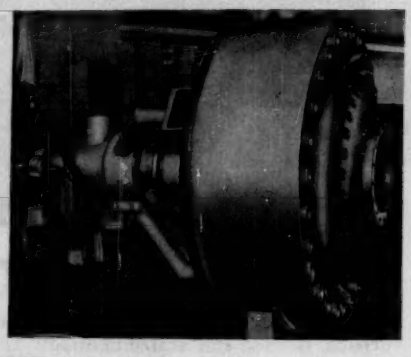
BETHLEHEM

BUILDS INTRICATE EQUIPMENT for Leading Chemical Processors

Modification to an existing

STEAM TUBE DRYER

Here is another example of how Bethlehem's engineering staff translates technical developments into significant design improvements. Although the design of this Steam Tube Dryer was made by a customer (a nationally known Nylon Producer) Bethlehem was asked to use its ingenuity to incorporate sealing gland, stuffing boxes, etc. to prevent leakage; reduce loss of blanketing atmosphere. Material of construction was Stainless Steel.



See 8-page catalog in C. E. C. for complete facilities of Process Equipment Division of

BETHLEHEM FOUNDRY & MACHINE CO.

BETHLEHEM, PENNA.

Bethlehem manufactures vessels in cast iron and fabricated steel, stainless steel, alloys, and clad; to ASME Code, other specifications, and company standards. X-ray and other test techniques assure sound construction for demanding service.

WRITE FOR BULLETIN 600 to learn more about BETHLEHEM processing vessels for reaction, agitation, heat transfer, distillation, sublimation, crystallization, drying.

New Line **of corrosion-resistant needle valves**

MARSH *Needle Valves*

in 316 STAINLESS STEEL

Throttle flow and throttle corrosion with this new valve series that gives you the superlative construction of Marsh Needle Valves with the corrosion-resistance of 316 stainless steel.

Here is a valve that gives you precision throttling and tight closure on pressures from a few pounds to 6000 psi. Wide temperature range, too—from minus 100°F. to plus 500°F. —as a result of the Marsh "Marpak" packing system utilizing precision moulded Teflon.

New 316 stainless series (series 1936) is identified by blue handle. Sizes from ¼" to 1"; globe, angle, and panel mounted patterns.

Marsh Needle Valves are also available in 416 stainless steel (identified by green handles) and in alloy steel (identified by yellow handles).

Ask for bulletin NV-3

MARSH INSTRUMENT COMPANY, Dept. 24, Skokie, Ill.
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co. (Canada) Ltd., 8487 183rd St., Edmonton, Alberta
Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

LITERATURE . . .

Hammer Mill.....with extra heavy manganese steel liners & breaker plates, oversize shafts, massive parts & reinforcements which defy shock & wear, reduce downtime. Catalog.
155 *Williams Patent Crusher

Jaw Crusher.....with cast steel frame, anti-friction side bearings and bumper bearings are covered in detail in Bulletin C12-B12. Sizes from 2¼" x 3½" to 36" x 48".
139d *Denver Equipment Co.

Mills.....Complete information on "Jet-O-Mizer" Mills, "Jet-O-Clone" Dust Collectors, and testing and custom grinding services is now available on request.
141 *Fluid Energy Processing & Equip.

Mills, Ball & Rod.....in sizes 10' x 20'. All steel construction for wet or dry grinding systems. Additional information contained in Bul. B2-B20.
139c *Denver Equipment Co.

Mixer.....Model 4LP Z-Blade-Micro-Mixer is designed to mix ½ to 2 ounce batches of liquid-solid combinations. Further details on this mixer are available.
188A Atlantic Research Corp.

Mixers.....New Shear-Flow continuous mixers cut processing cost, eliminate costly equipment and offer versatile adaptability. Further information in Bulletin RL-200.
172 *Gabb Special Products, Inc.

Process Equipment.....“Sub-A” Flotation is available in sizes from 16" x 16" to 72" x 72". “Cell-to-Cell”, “Free-Flow”, and Type “M” Bulletin F10-B86.
139f *Denver Equipment Co.

Processing Equipment.....A 32 page report on the latest designs and costs of impervious graphite processing equipment is provided to keep processing people up to date.
81 *Falls Industries, Inc.

Processing Equipment.....Condensed catalog of materials handling and processing equipment provides a quick but comprehensive view of Transvair pneumatic systems.
188B The Young Machinery Co.

Processing vessels.....Bulletin 600 gives specific information about processing vessels for reaction, agitation, heat transfer, distillation, etc.
T188 *Bethlehem Foundry & Mach. Co.

Purifiers.....Hi-eF Purifiers have patented two-stage principle of separation with no moving parts. Special Manual 803 contains data on 13 types of separators.
B186 *The V. D. Anderson Company

Reagent Feeders.....Both wet and dry feeders are available. Many standard units in stock. Complete information on these feeders in Bulletin F6-B8.
139e *Denver Equipment Co.

Samplers.....Continuous mechanical & automatic types for dry, solution or slurry sampling. Complete sampling plants & sample processing equipment. Bul. S1-B4.
139j *Denver Equipment Co.

Screens.....for efficient wet or dry screening. “True-Circle eccentric action. Sizes to 6' x 14' in stock. Trommel Screens in sizes from 30" x 60" x 120". Bul. S3-B15.
139k *Denver Equipment Co.

* From advertisement, this issue

Spiral Rake Thickeners.....move settled materials to center in one revolution. Acid proof construction available. Further information in Bul. T5-B6.
1391 *Denver Equipment Co.

Tornado Mill.....offers versatility in speed, in size of particles it handles, & in the rate of production. The 360 degree screen provides full working area.
153 *F. J. Stokes Corp.

Pumps, Fans, Compressors

Compressors, Centrifugal.....Bulletin 175 available on Isotemp Compressors along with Bul. 150 on Centrifugal Oxygen Compressors or Bul. 160 on Recip. Process Comp.
18-19 *Clark Bros. Co.

Compressor, Piston.....Unique Ringless Piston and Frictionless Piston Rod Stuffing Box requires little or no maintenance. For air, oxygen, hydrogen, etc. Information.
T183 *Sulzer Bros. Inc.

Compressor, Vertical.....Catalog describes complete line of vertical package compressors that are standardized for 125 psi in sizes 50 to 2000 hp.
189A Bury Compressor Co.

Pump, Vertical Centrifugal.....for handling frothy liquids or coarse, sand slurries, constant or intermittent flow. Capacity to 450 gpm. Bulletin P10-B5.
139h *Denver Equipment Co.

Pumps.....Durcopumps are available, standard or self-priming, with heads to 345 ft. and capacities to 3500 gpm. Bulletin P-4-100 for additional information.
125 *The Duriron Co., Inc.

Pumps.....satisfy virtually all pumping requirements and feature higher speeds, non-overloading power characteristics and steep head-capacity stability. Colorful booklet.
137 *Johnson Pump Co.

Pumps.....Complete new line of Stainless Steel and other alloy pumps at 100% rated speed on thin liquids. Mechanical seals, integral relief valves, etc. Catalog MC.
152 *Viking Pump Co.

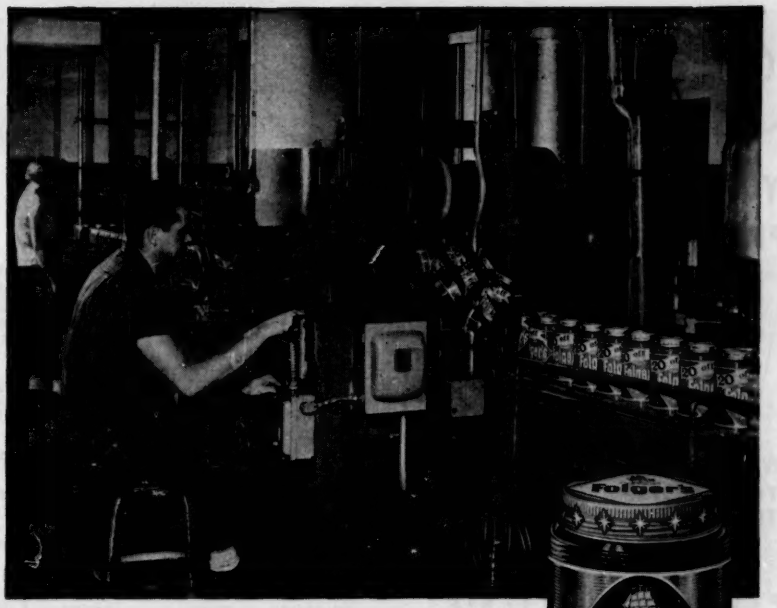
Pumps.....Single-stage, end suction pumps are available in full range of sizes to handle from 10 GPM to 2000 GPM. Corrosion-resistant metals protect all surfaces. Bul. 500.
144 *The Weinman Pump Mfg. Co.

Pumps, Diaphragm.....Stroke can be adjusted while pump is operating. Sizes 1" to 10" simplex and duplex, capacity to 1000 g.p.m. Bulletin P8-B12 offered.
139g *Denver Equipment Co.

Pumps, SRL (Rubber Lined).....Now available in "TRU-GLANDLESS" construction. No sealing water, no packing glands, no slurry dilution. Additional information in Bul. P9-B28.
1391 *Denver Equipment Co.

Rotary Compressors & Vacuum Pumps.....handle air and gases from 30 to 3300 cfm at pressures to 125 lb. gage. Vibration free, can be installed anywhere. Lit.
55b *Fuller Co.

* From advertisement, this issue



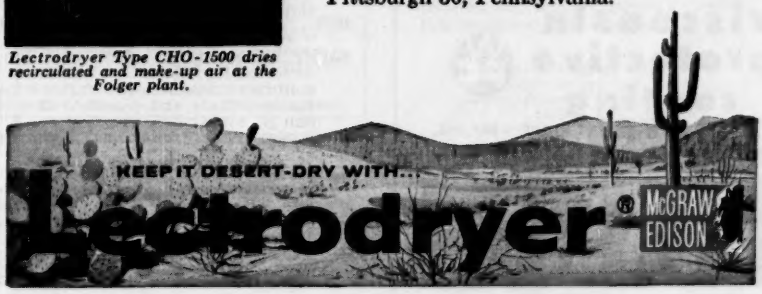
Dry air speeds packaging ...protects quality of instant coffee

Instant coffee absorbs moisture fast. If this happens before it reaches the coffee cup—say when it's being packed—it can clog up packaging machines, ruin the quality of the coffee. In Houston, where humidity stays high for long stretches, the makers of Folger's coffee solved the problem by installing a Lectrodryer that keeps relative humidity at 25% to 35%.

Controlled dryness by Lectrodryer has been the answer to many problems caused by moisture; gumming up of hygroscopic powders, corrosion of metal, air line freezeups, and contamination of drugs, chemicals, liquids, gases.

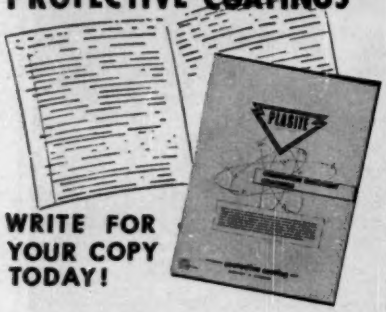
Lectrodryer Type CHO-1500 dries recirculated and make-up air at the Folger plant.

For a Guide in Planning your own drying system, write for Lectrodryer's Case History Sheets, which give details on how many of these problems were solved. Tell us where you're having trouble with moisture. Pittsburgh Lectrodryer Division, McGraw-Edison Company, 303 32nd Street, Pittsburgh 30, Pennsylvania.



Simplify

YOUR SELECTION OF PROTECTIVE COATINGS



WRITE FOR YOUR COPY TODAY!

PROVEN IN THE PROCESS INDUSTRIES

- STEEL TANK LINING
- CONCRETE TANK LINING
- PROTECTION OF STRUCTURAL STEEL, FUME DUCTS AND EQUIPMENT
- CONCRETE FLOORS
- TANK CARS

FOR IMMERSION SERVICE
FOR HEAVY DUTY MAINTENANCE SERVICE

COLD SET COATINGS

HEAVY BUILD using standard spray or brush methods.

WIDE CHEMICAL RESISTANCE to acids, caustic solvents, salts, de-ionized water, and aqueous solutions.

HIGH TEMPERATURE RESISTANCE not affected by thermal shock.

AIR DRY field applications.

EXCELLENT BOND — No Primers on white metal blasted surface.

OTHER PLASITE PRODUCTS INCLUDE: CAULKING COMPOUNDS
PRIMERS
BAKING COATINGS

wisconsin protective coating corp (WPC) GREEN BAY, WIS.

REPRESENTED IN PRINCIPAL INDUSTRIAL AREAS

PLASITE

LITERATURE . . .

Rotary pumps.....Gearex pumps provide positive displacement, pulseless flow, quiet, vibrationless operation. Horizontal or vertical models. Bul. G-3 is available.
163 *Sier-Bath Gear & Pump Co., Inc.

Services & Miscellaneous

Control Systems.....Bulletin entitled "Statistical Data Reduction and Control Systems" discusses methods for increasing efficiency of data reduction and automation systems.
196A Monitor Systems, Inc.

Corrosion Charts.....Corrosive effects of almost 400 different materials on 16 types of metals are contained in bulletin prepared with multi-company cooperation.
190B Nooter Corp.

Corrosion Computer.....4 inch by 8 inch card that works similarly to a slide rule and tells in seconds how each of eight types of metals reacts to 141 chemical agents.
190C H. M. Harper Co.

Hydraulic Systems.....Application of packaged hydraulic systems to solve a wide range of process control problems is subject of a 6-page bulletin. Advantages are listed.
190D Vickers Inc.

Knife Cutter.....engineered for tough size reduction jobs with superior results. Their application and versatility are practically unlimited. Bulletin 213.
150 *Sprout, Waldron & Co., Inc.

Lab Apparatus.....A complete line of quality ware . . crucibles, dishes, electrodes, gauze, sheet, strip, foil, wire and tubing. New catalog is available.
4 *J. Bishop & Co.

Lubricating System.....Whatever your field, engineers will be glad to study your requirements and make specific recommendations. Catalog available.
199 *Manzel

Power Conversion.....Brochure deals with application of solid state and magnetic devices to power conversion and describes complete line of supplies and devices.
190E Power Sources, Inc.

Processes.....Compacting process maintains control over all variables. Both density and solubility rates are easier to control. Information is available on request.
147 *Allis-Chalmers

Products Catalog.....30-page illustrated catalog describes vacuum ovens, diffused chambers, radiant ovens, dribox vacuum bake systems and modular controlled atmosphere enclosures.
190F Temperature Engineering Corp.

Safety Equipment.....The new Protectoseal Red Book is available and contains flammables engineering fundamentals and complete line of safety containers, etc.
R185a *The Protectoseal Company

Sound Barriers.....12-page engineering report explains how to calculate effectiveness of materials as sound barriers. Includes section on "noise criterion" charts.
190G Lead Industries Assoc.

* From advertisement, this issue

PROFESSIONAL SERVICES

E. J. COREL
ENGINEER
Chlorine—Soda Ash—Perchlorethylene
Pigments and Related Products
Design—Reports—Operation
413 Rose Blvd. Akron, Ohio
Tele: Akron, O. TE 64271

THOS. HENDRICKSON, D. Sc.
Ore Testing Consultant
Process Development—Project Supervisor
Plant Efficiency and Improvement Studies
815 19th Street Golden, Colorado
Phone: CRestview 9-3695

THE KULJIAN CORPORATION
Consultants • Engineers • Constructors
Chemical • Industrial • Process
1200 N. Broad St. Phila. 21, Pa.
Offices Throughout the World

PETER F. LOFTUS CORPORATION
Design and Consulting Engineers
Electrical • Mechanical • Structural
Civil • Nuclear • Architectural
First National Bank Building
Pittsburgh 22, Pennsylvania

CHAS. T. MAIN, INC.
Engineers
Industrial plants
Reports Design Construction Supervision
Boston, Massachusetts Charlotte, North Carolina

FOSTER D. SNELL, INC.
Chemical & Engineering Consultants
Research, Process Developments, Pilot Plant Studies. Plant Design. Location Studies Construction Supervision. Start-up & Operation. Equipment Design. Packaging & Materials Handling Studies. Cost Analyses. Trouble Shooting.
29 W. 15th St. WA-4-8800 New York 11, N. Y.

VON BREE, INC.
Consulting Chemical Engineers
SPECIALISTS IN SULFURIC
Catalyst • Process • Design
Inspections • Evaluations
Pollution Control
20 Monterry Drive Newark, Delaware
ENdicott 8-3674

Consult these SPECIALISTS
Let them save your time by bringing their broad experience in their specialty to bear on your problems.

Some Current Areas of Need

- POWERPLANT TEST AND ANALYSIS
- INSTRUMENTATION AND CONTROL DESIGN
- POWERPLANT EQUIPMENT DESIGN
- REACTOR NUCLEAR ANALYSIS
- THEORETICAL PHYSICS (PhD)
- EXPERIMENTAL PHYSICS
- ENGINEERING STATISTICS (PhD)
- REACTOR MECHANICAL DESIGN
- HYDRO-THERMAL ENGINEERING COMPUTATIONS
- COOLANT TECHNOLOGY
- NUMERICAL ANALYSIS
- REACTOR EQUIPMENT DESIGN

Building on a succession of achievements in reactor applications and nuclear development, The Knolls Atomic Power Laboratory is currently expanding its program scope in a number of new directions—both exploratory and developmental.

Security restrictions prevent the identification of projects, or a detailed disclosure of the unique professional opportunities now open at KAPL. However, within these limitations we would be pleased to discuss the unclassified portions of our programs and describe the Laboratory's specialized experimental, computational and test facilities to nuclear scientists and engineers interested in reactor power plant development.

NEW OPENINGS ANNOUNCED

FOR NUCLEAR ENGINEERS AND SCIENTISTS

Qualified candidates, with experience in one or more of the fields listed at the left are invited to inquire about positions now available.

Address your inquiry in strict professional confidence to Mr. A. J. Scipione, Dept. 65-WB. U. S. Citizenship and appropriate engineering or scientific degree required.

Knolls Atomic Power Laboratory

OPERATED FOR A.E.C. BY

GENERAL ELECTRIC

Schenectady, New York

METALLURGIST

with production experience in wire drawing, preferably stainless steel. Position: Head of department. Our employees know of this opening.

P-5524, Chemical Engineering
520 N. Michigan Ave., Chicago 11, Ill.

TECHNICAL SALES SERVICE

Reside Midwest, work from home, representing manufacturer paper mill equipment. Experience in pulp and paper or engineering sales desirable. Travel as required. Send complete resume with photograph. Salary open. All replies confidential. Send reply to

P-5843, Chemical Engineering
Class. Adv. Div., P. O. Box 12, N. Y. 36, N. Y.

"Put Yourself in the Other Fellow's Place"

TO EMPLOYERS

TO EMPLOYEES

Letters written offering Employment or applying for same are written with the hope of satisfying a current need. An answer, regardless of whether it is favorable or not, is usually expected.
MR. EMPLOYER, won't you remove the mystery about the status of an employee's application by acknowledging all applicants and not just the promising candidates.
MR. EMPLOYEE you, too, can help by acknowledging applications and job offers. This would encourage more companies to answer position wanted ads in this section. We make this suggestion in a spirit of helpful cooperation between employers and employees.
This section will be the more useful to all as a result of this consideration.

Classified Advertising Division

McGraw-Hill Publishing Co., Inc.
330 West 42nd St., New York 36, N. Y.

Wanted Electrical, Mechanical or Chemical Engineering graduates to be trained as

SALES ENGINEERS

For Chicago, Cincinnati and Boston. Prefer men between 25 and 32 years of age who have had industrial process experience. Successful applicants will be given a three-month factory course starting February 1, 1961.

Write Harry E. Beane, Vice President

THE BRISTOL COMPANY
Waterbury 20, Connecticut

SUPERVISOR

for Wire Drawing Department. Supervisory and metallurgical experience essential. Our employees know of this opening.

P-5525, Chemical Engineering
520 N. Michigan Ave., Chicago 11, Ill.

RESEARCH DIRECTOR

$15,000

Young aggressive organization desires man on PHD or Masters level to assume complete charge of department engaged in research & development in the polymer, rubber, plastics and adhesive field. Client assume all expenses.

MONARCH PERSONNEL
28 East Jackson Chicago 4, Illinois

ADDITIONAL EMPLOYMENT OPPORTUNITIES ADVERTISING on following page

SEMICONDUCTOR ENGINEERS and SCIENTISTS

SHOCKLEY TRANSISTOR
(Unit of Clevite Transistor)

Offers career opportunities to experienced engineers. Key posts immediately available for:

- PHYSICISTS
- PHYSICAL CHEMISTS
- METALLURGISTS
- ELECTRONIC ENGINEERS
- MECHANICAL ENGINEERS
- CHEMICAL ENGINEERS

Challenging work assignments involving fundamental research and development, circuit design and applications, manufacturing and product engineering, process engineering and supervision.

For further information concerning career opportunities call R. E. Caron, Engineering Placement Director, COLLECT at DA 1-8733 or send résumé in complete confidence to him at

Shockley TRANSISTOR
335 San Antonio Road
Mountain View, California

Employment Opportunities

▶ **Displayed Rates**—$54 per inch for all ads except on a contract basis; contract rates on request. An advertising inch is measured ⅞ in. vertically on a column; 3 columns, 30 in. per page. Subject to the usual agency commission.

▶ **Undisplayed Rates**—$2.10 per line, 3 lines minimum. To figure advance payment count 5 average words as a line; box number count as 1 line. 10% discount if full payment is made in advance for 4 consecutive insertions. Not subject to agency commission.

Equipment Searchlight

CE's Searchlight spots the big bargains in used, resale and rented equipment. Check this issue's listings—most complete in the field—for items you need now.

▶ **Coverage** — National. Equipment and facilities—used, resale and rental—for the process industries. For sale, wanted, for rent.

▶ **Rates**—$21.75 per inch for all ads except on a contract basis; contract rates on request. An advertising inch is measured ⅞ in. vertically on a column; 3 columns, 30 in. per page. Ads acceptable only in display style.

▶ **Closing date**—February 6th issue closes January 13th. Send all new ads to Chemical Engineering, Classified Adv. Division, P. O. Box 12, New York 36, N. Y.

ASSISTANT PLANT ENGINEER

Leading multi-plant, producer of fertilizers, needs Assistant Plant Engineer for integrated sulfuric, phosphoric and fertilizer plant in Gulf Coast area. Requirements: B.S.M.E. degree or equivalent, and a minimum of two years direct maintenance experience in administering maintenance program, plant modifications and new construction in plants of this type.

Excellent starting salary and Company benefits with opportunity for advancement. Resumes submitted will be given prompt attention and will be maintained in confidence.

P-5842, Chemical Engineering
520 N. Michigan Ave., Chicago 11, Ill.

CHEMICAL ENGINEER

PhD or M.S.

Experienced in commercial chemical development for West Coast chemical company, for position as Assistant to Vice President Research and Development. Age 30 to 40.

Send complete resume to:

P-5814—Chemical Engineering
1125 W. 6th St., Los Angeles 17, Calif.

POSITION VACANT

Wanted: Graduate Chemical Engineers with a minimum of five years experience and Research and Development Chemist with B.S. or M.S. Degree and at least five years experience in research and development activities. Work will be process and product development in phosphate mining and processing operations in large plant with major expansion program now underway. Permanent location in Central Florida. Excellent opportunity for advancement. Salary commensurate with experience. Send detailed resume to Personnel Department, American Cyanamid Company, Brewster, Florida.

EMPLOYMENT SERVICES

Better Positions—$6,000 to $50,000. Want a substantial salary increase, more opportunity or different location? This national 50 year old service connects you with best openings. You pay us only nominal fee for negotiations: this we refund when employer pays placement fee. Present position protected. In complete confidence, write for particulars. R. W. Bixby, Inc., 653 Brisbane Bldg., Buffalo 3, N. Y.

1—Blender, #12 Sturtevant, 450 cu. ft. s.s. complete with 40 hp exp. proof motor and Horsburgh-Scot drive —near new condition.

1—Kemp carbon dioxide removal unit 6000 CHF inert gas capacity — nearly new condition.

MISC. PUMPS, MOTORS, DRIVES—TANKS

COMPLETE SURPLUS LIST AVAILABLE UPON REQUEST.

THE CHEMSTRAND CORPORATION
DECATUR, ALABAMA
ATTN: C. G. HUDSON

CIRCLE A ON READER SERVICE CARD

Equipment Wanted

PEBBLE MILLS, USED

We need three jacketed and porcelain-lined pebble mills, 5' x 6' or similar, in operating condition. Drive and pebble charge not necessary.

ARTHUR D. LITTLE, INC.
35 Acorn Park Cambridge 40, Massachusetts
Attn: W. R. Byrnes

CIRCLE B ON READER SERVICE CARD

PROFIT SAVERS

NEW BLAW-KNOX ROTOCEL

20' dia carrying 18 equally sized cells. Complete with Feed & Slurry Tanks. Heat Exchangers, Pumps, Instruments etc.

Tremendous Saving

ME MACHINERY AND EQUIPMENT CO.
123 Townsend St. · San Francisco 7, Calif.

CIRCLE C ON READER SERVICE CARD

LOCOMOTIVES—RR CARS & CRANES
9 Gen. Elec. 20, 25, 45, 65, 80, 100 & 125 Ton
25-Ton Industrial Brownhoist, 60' Boom Crane
200 Box & Gondola Ry. Cars

PLANT EQUIPMENT
4' Traylor TY Gyratory Crusher
2—Wemco 2M-HHS Plants
No. 5060 Dixie Mogul Hammermill 500 HP
No. 1 Sturtevant Rotary Fine Reduction Crusher
F65 Syntron Grizzley Feeder
10—1½ & 2 Yd. V-Shape Dump Cars
2—5' x 8' KVS Air Swept Ball Tube Mills
Ball Mills: No. 56, 5' x 4' x 9' & 7' x 22'
Hardinge Mills: 3'x9", 3'x24", & 10'x48"
Rod Mills: 4' x 11', 6' x 12' & 7' x 15'
Jaw Crushers: 10" x 20", 14" x 28", 15" x 24", 18" x 36", 30" x 36", 48" x 72"
Crushers, Fine Reduction: 22", 2', 3', 4', 5½, & 7' 84S Cone
Rotary Dryers: 3'x30', 5'x30', 6'x70' & 8'x80'
Rotary Kilns: 36" x 30', 6' x 70', 7' x 120' & 9' x 160'
Roto Louvre #207-10 Type 316 SS, Link Belt
60—1½, 2 & 4 yd Dump Cars
Laboratory Rotary Kiln, 36" x 30", Complete
4' x 10' Tyler-Hummer Electric Vibrating Screen
2'x6' & 3'x12' Seco Single Deck Vibrating Screen
2—6' x 12' Allis Chalmers 2 Deck Vibrating Screens
16' Gayco Centrifugal Air Separator
6—30" x 32" Dings Magnetic Head Pulleys
690', 2200', 3068' & 3600'-I.R. Compressors
41000 CFM Sly Dust Collector
2000 Tons Steel Sheet Piling, 10' to 78'
WANT BUY DRYERS — KILNS — CRUSHERS

R. C. STANHOPE, INC.
60 E. 42nd St. New York 17, N. Y.
Tel. MU. 2-3075

CIRCLE D ON READER SERVICE CARD

Values Galore for '61!

1—Devine 10 Shelf Vac. Shelf Dryer
1—Kent High Speed 3 Roll Mill 13"x32"
1—Southwark Hyd. Press 15"x15"-25 Ton
1—Charlotte N20 SS Colloid Mill
2—Sparkler S.S. Filters 18" & 8"
5—Hercules 316SS Filters 16" & 8" Sq.
1—Day 50 Gal. S.S. Sigma Blade Mixer.
1—Day 50 Gal. Jack. Sigma Blade Mixer.
5—Worthite SS Pumps 8" x 6"; 3" x 2"; 2" x 1½"
2—S.S. Spiral Blenders 1000# & 1800#.
1—Raymond 36" Double Whizzer Separator
5—Rotex Screens 20"x48" to 60"x84" S.S. Screens.
1—Cyclotherm Boiler 20 HP-Oil Fired.

We Buy Your Surplus Send Us Your Inquiries

The Machinery & Equipment Co. Used Div.
Haring Equipment Corp.
Newark 5, N. J. Market 2-3103

CIRCLE E ON READER SERVICE CARD

EXCLUSIVE RIGHTS OFFERED TO MANUFACTURERS OF SPRAY DRYERS

Unique new conception Parallel Spray Dryer, only 32 ft. high, 1000 lbs. water evap/hr. 100% unbroken heads recovered. Instant-soluble products, foods, vegetable chemicals, soaps. By designer original patented Concurrent Dryer. Best ref. Any solids-containing liquids.

Write Secheurs Atomiseurs Co., 11 Ave., Grande Bretagne, Monte Carlo, Monaco.

CIRCLE F ON READER SERVICE CARD

FOR SALE

Periodic Chart—laminated pocket size; Elements, atomic weights, densities, etc. Send $1.00—R. and S. Laminating Company, Box 111, White Plains, New York.

SEASON'S GREETINGS!

CENTRIFUGES

2—Sharples C-20 and C-27 Super-D-Hydrator, 316 S.S.
1—Bird 18" x 28", Solid Bowl, Continuous, 304 S.S.
1—Bird 32" x 50", Solid Bowl, Continuous, 316 S.S.
1—Bird 36" x 50", Solid Bowl, Continuous, 347 S.S.
3—Sharples PY14, PN14 Super-D-Canters 316 S.S.
1—Tolhurst 26" susp. Rubber Imperforate Basket.
2—Fletcher 48" Suspended 316 S.S. Perforated Basket.
2—Sharples #16, 304 S.S., 3 HP motor.

REACTORS—EVAPS—CONDS—TANKS

1—Glascote 500 gal. glass lined jacketed agitated Reactor.
1—150 gal. 304 S.S. jacketed agitated Reactor.
3—Pfaudler 200 gal. glass lined jacketed Kettles.
1—650 gal. 304 S.S. Reactor with 100 sq. ft. Bayonet Heater.
1—Pfaudler 12" wiped film Evaporator.
1—700 sq. ft. Buflovak 304 S. S. forced circulation Evaporator.
1—550 sq. ft. Buflovak monel single effect Evaporator.
1—7500 gal. 316 S.S. Vert. Storage Tank, 7' x 25', 50 psi.
1—500 gal. S.S. Mixing Tank with nickel coils.
6—7500, 6000 and 2000 gal. Rubber Lined Tanks.
4—1000 gal. 304 S.S. Tanks, 5'6" x 6'.
1—1500 gal. Stainless Pressure Tank, 5' x 10', 90#.
1—2,000 gal. horiz. 304 S.S. tank 5' x 12'.
1—2500 gal. vertical 304 S.S. Tank, 8' x 7'.
1—12,000 gal. horiz. steel Pressure Tank, 7'6" x 36', 200 psi.
6—Stainless Heat Exchangers; 1220, 786, 536, 370, 315, 250 sq. ft.
1—24" dia. x 35', 304 S.S. Bubble Cap Column.

FILTERS

1—#5 Sweetland Filter 304 S.S. 120 sq. ft.
1—Oliver 6' dia. Horizontal Filter, 316 S.S.
1—Oliver 5' x 6' Steel Rotary Vacuum Precoat Filter.
1—U.S. 200 sq. ft. 304 S.S. Auto-Jet Filter.
1—Hercules 400 sq. ft. 304 S.S. Pressure Filter.
1—Oliver 5'3" x 8' Steel Rotary Vacuum, vaportite housing.
1—Feinc 5' x 6' Stainless Steel Rotary Vacuum Filter.
2—#10 Sweetland Filters, 27 leaves, 4" centers, 250 sq. ft.
4—36" x 36" alum. P & E, 65 chambers, 1½" cake, hyd. clos.

DRYERS

1—Buflovak Vacuum Shelf with 20—60" x 80" shelves.
1—Devine Vacuum Shelf with 10—40" x 43" shelves.
2—Buflovak 42" x 120", atmospheric double drum Dryers, complete.
1—Buflovak 32" x 90" Atmos. Twin Drum Dryer.
2—Devine 4' x 9', single drum, atmospheric.
1—Buflovak 3' x 10' Rotary Vacuum Dryer.
1—Baker Perkins 5'6" x 6' Rotary Vacuum Dryer.
2—Buflovak 5' x 30', 3' x 7'6" Rotary Vacuum Dryers 316 S.S.
3—Louisville Rotary Steam Tube 5' x 25', 6' x 35', 6' x 50'.
2—Louisville 8' x 50' Stainless Steel lined Rotary Dryers.
9—Rotary Dryers 34" x 30', 4' x 40', 6' x 50', 6' x 60' 7' x 80', 8' x 87'.
1—Traylor 30" x 18' Stainless Steel Rotary Dryer.
2—Link Belt, 7'5" x 25', 6'4" x 24", S.S. Louvre Dryers.
2—Atmos. Tray Dryers, 16 shelves, 40" x 24".
1—P&S 10' wide Apron Conveyor Dryer 48' long.
2—10' and 4' dia. 304 S.S. Spray Dryers.

MIXERS

1—Farrel-Birmingham "Midget" Banbury Mixer.
2—Day Imperial 150 gal. jktd. double arm.
1—Baker Perkins 100 gal. jacketed double, arm, 30 HP.
1—Baker Perkins 50 gal. jacketed, double-arm.
5—Day "Cincinnatus" double arm, 250 and 100 gal.
2—Steel jacketed Powder Mixers, 225 and 350 cu. ft.
1—Patterson 6' dia. Conical Blender 15 HP.
1—3' dia. Simpson Intensive Mixer.
1—Patterson Kelly 150 cu. ft. Twin Shell Blender.

MISCELLANEOUS

1—Farrel Birmingham 8" x 16" 2 Roll Chrome Plated Mill.
2—Hardinge 5' x 22" steel lined conical Ball Mills.
4—Mikro Pulverizers 4TH, 1 SH, 1 SI and Bantam.
3—Abbe 2½" x 3' porcelain lined Pebble Mill XP motor.
1—Raymond 10" vert. Mill, 10 HP.
1—No. 1 Ball & Jewell Rotary Cutter.
1—#18 Cumberland Rotary Cutter.
3—Swenson Walker Continuous Crystallizers, 24" x 30' sections.
2—#842 Rotex Sifters 60" x 84" double deck.
1—#24 Rotex Sifter, 20" x 64", Quadruple deck.
1—#81 Day Roball Sifter 40" x 120" single deck.
5—Day Roball Sifters, 40" x 120", 40" x 84", Double Deck.
3—Nash H6 Vacuum Pumps.
25—Chlorimet, Durimet and Duriron Centrifugal Pumps 1½" to 6".
4—Stokes Rotary Tablet Machines DD2-DD52-D53-RB2.

Partial List of Values — Send for Complete Circular

BRILL EQUIPMENT COMPANY

35-61 JABEZ ST., NEWARK 5, N. J. Tel: MArket 3-7420—N. Y. Tel. RE 2-0820
TEXAS OFFICE: 4101 San Jacinto St., Houston 4, Texas—Tel: JAckson 6-1351

CIRCLE G ON READER SERVICE CARD

Buffalo 32"x90" Double Drum Dryer
New 4000 gal. Stainless Tank
Spr. Wald 10,000# Spiral Mixer
SEND FOR LISTINGS
STEIN EQUIPMENT CO.
107—8th Street Sterling 8-1944 Brooklyn 15, N. Y.

CIRCLE H ON READER SERVICE CARD

BEST BUY

STAINLESS PILOT CENTRIFUGE
IN STOCK

Bird 12" dia suspended solid basket Stainless Steel Centrifuge with 2 HP 3500 RPM motor directly connected. Vapor tite construction. Complete with skimmer and plow.

JUST LIKE NEW

ME [illegible]

CIRCLE J ON READER SERVICE CARD

FILTER PRESSES—6" lead P&F w/pump, 18x18 (26 chamber), 30x30 (11 chamber)

MILLS—Hardinge Conical, 3'x8", 3'x24", 5'x22", 8'x36", 8'x48", 6'x12' rod w/200 HP

VACUUM PUMPS—115 CFM Beach Russ RP w/5 HP motors, Leiman 105 CFM, Dorr Oliver 200 CFM-piston

DRYERS—ROTARY—24"x22', 3'x24', 4'x40' 5'x50', 7'x58', all w/motor drives.

MIXERS—New 3 qt. sigma/jacketed, 5 gal. Bramley 5 HP vac./jack., 12 gal. sigma, 22 cu. ft. ribbon blender.

E. W. LAWLER has stopped piloting International Jet Liners—Full time super service now for YOU.

MIKRO BANTAM w/vari feed drive, 4TH Mikro (unused) w/Mikro collector & 3x5 Tyler screens for closed circuit.

LAWLER COMPANY
Durham Ave. Liberty 9-0245 Metuchen, N. J.

CIRCLE K ON READER SERVICE CARD

LOEB OFFERINGS

Autoclave: 50 gal. Struthers Wells, st. st.
Centrifugal: AT&M 60" st. st. perf.
Dewaterers: Davenport 3A, bronze hd. 3 hp.
Disintegrator: Rietz RD-12, 15 hp.
Dryers: Devine 2 x 4' vac. drum. st. steel.
Dryers: Bowen lab. spray, st. steel.
Dryer: American atmospheric, 24 x 48".
Column: 24" x 22', 316 stain. steel.
Evaporator: Buflovak st. st., 94 sq. ft.
Filter: Sweetland #5 st. st. lined.
Filter: Oliver precoat 12 x 2" st. steel.
Filter: Eimco st. st., drum 16" x 12".
Filter Press: Shriver 24" St. steel.
Homogenizers-Disperser: Tri-Homo #10, #4.
Homogenizers: 25, 50, 125, 200, 1200 GPH.
Kettles: st. steel with and without ag.
Mill: Fitz model D-6 st. steel, 7½ hp.
Mill: J. H. Day 16 x 40" 3-roll high speed.
Centrifugal: Tolhurst 48" st. steel.
Mixers: Dbl. and sgl. arms sigma blade. Dry Powder, various sizes. Abbe Dispersal 1½ gal., 1 hp.
Pumps: Rotary, gear, centrif., vacuum.
Percolator: Pfaudler 300 gal. st. steel.
Dryer: Proctor & Schwartz 6-tray St. steel.
Tablet Press: Stokes DD2, 23 station.
Vacuum Pans, 42" and 72" stain. steel.

LOEB [illegible] TELEPHONE STATE 2-4321
EQUIPMENT SUPPLY CO.
320 WEST SUPERIOR ST. CHICAGO 22 ILLINOIS

CIRCLE L ON READER SERVICE CARD

START the NEW YEAR RIGHT

RE-APPRAISE YOUR EQUIPMENT POSITION
WHAT SHALL WE BUY? WHAT SHALL WE SELL?

SPECIAL OFFERING DIRECT FROM LOCATION
CONTINUOUS FINE GRINDING EQUIPMENT
Being Removed as Operations Terminate

2—Allis Chalmers 7' x 22' (2 Compartment) Compeb Ball Mills with Meehanite Liners; each driven by a magnetic-coupled 400 HP Motor

1—Allis Chalmers 9½ x 810 Preliminator or Continuous Ball Mill; Meehanite Liners, driven by a magnetic-coupled 400 HP Motor

3—Allis Chalmers 7' x 22' Continuous Ball Tube Mills, with Meehanite Liners, each driven by a magnetic coupled 400 HP Motor now operating in closed circuit with

3—Raymond 14 Ft. Double Whizzer Mechanical Air Separators, each driven by 75 HP Motor. May be purchased separately.

EVAPORATORS — DRYERS

Buflovak S/Steel Thermo-Recompression Evaporator; Sanitary with all accessories.
Buflovak S/Steel Dbl. Effect Evaporator Model 8½-60 D.
Pittsburg Lectro Dryers, Bac 25 and BWC 3400.
Devine Vac. Chamber Dryers, Double Door Model No. 36.
Stainless Lab. Drum Dryer, 8"x11½"
Bowen S/S Lab. Spray Dryer.
Louisville S/S Rotary Dryer, 30" x 28'; Link-Belt Roto-Louvre Dryer; Model 502-20.
Louisville MONEL Rotary Steam Tube; 54" x 35".

MILLS—PULVERIZERS

2 Stainless Micronizers 30".
Ball Mills and Pebble Mills by Abbe, Patterson, International Some Jacketed; up to 8'x8'.
Mikro Pulverizers up to No. 4's.
Fitzpatrick Comminutators; Models D, K and C; motorized.
American Ring Roll Crusher; 50 HP.
Mikro S/S Atomizers; Nos. 6 and 5.
Raymond Imp Mills; many sizes.
Williams Hammer Mills to 60 HP.

REACTORS — PRESSURE VESSELS

2 Stainless 400 gal. Reactors Jktd. Agtd. by Patterson and Struthers Wells.
Dorr-Oliver 500 gal. 5'x5' Stainless Thickener or Reactor.
Stainless Reactor, 2000 gal. Fully Jktd. Agitated.
Nickel Clad Reactor, 7'x11'6".
2 MONEL Reactors; 2800 gal. 6'6"x13"; ASME Jktd. & Intern.
3 Stainless Vert. Pressure Tanks; 42"x10'; closed dished heads.
6 Heavy Duty Stainless Tanks; 850 gal. with S/S Agitators.
Picaudler Gl. Lined Reactors; all sizes from 50 to 1000 gal.
Mojonnier Stainless Vac. Pans; 3'x10' and 6'x12'; others.

CENTRIFUGES

Stainless Centrifugals from 30" to 60"; A.T.&M. Tolhurst, Fletcher, etc.
2 Sharples Stainless Steel Model PN14 Super-D-Canters.
4311 S 1 Sharples C 27 Super-D-Hydrator in Type 316 Stainless with 40 HP Motor.
5147 S 13-14 Two Bird Continuous Screen Type Horizontal Centrifuges; Monel & S.S.; 24" x 24".
2 Bird Rubber Covered, 48" with Plows; Fume Tight; 40 HP.

SPOTLIGHT SPECIALS

Komarek Greaves Briquetting Presses; 75 HP
Stokes Double Chamber Impregnators
Stokes Model #280 (80 Ton) Press; 7½ HP
Stokes # 252 Aut. Closure Press; 150 HP
Flash Drying System in Type 316 Stainless
Hardinge Conical Ball Mill; 8" x 36"
F-B Unused Late Type 2 Roll Mills; 14" x 30" with Uni-Drives

MIXERS ALL TYPES

Baker-Perkins Jktd. 5 gal. UNE-7, Dbl. Arm Mixer with pressure cover; 30 HP.
Readco Jktd. 15 gal. Dbl. Arm Sigma Blade Mixer.
Patterson Conaform S/S Vac. Blender, 13.7 cu. ft. Jacketed.
Stainless Steel 150 gal. Jktd. Dbl. Arm Mixer with Vac. Cover; Hydr. Tilt;
Other Baker Perkins Jktd. Mixers, 100, 200 and 300 gal.
J. H. Day Cincinnatus Dbl. Arm Mixer; 300 gal. STAINLESS Jacketed.
NOW IN STOCK for IMMEDIATE DELIVERY. ALL SIZES FALCON Ribbon Blenders in Steel or Stainless.

FILTERS — FILTER PRESSES

4 Pressure Filters 30"x56" Type 316 Stainless; 100 sq. ft.
Sparkler S/S Filter Model 14 S 4.
Sparkler Steel Filter Model 33 S 17.

OLIVER PRECOAT FILTERS

3"x2" Monel. 5'3"x8' Stainless.
(2) 5'3"x3" Steel or Rubber.
Feinc S/S Rot. Vac. Filter 3'x1'.
Oliver Cont. Rot. Vacuum Filter.
Panel Type; 8'x8' and 8'x10'.
S/S Nutsche Type Filter; 6'x2'.
Bowser Filter with Pump; 2000 GPH.
Shriver and Sperry Plate & Frame Filter Presses up to 42" in Cast Iron, Stainless, Ni-Resist, Rubber Covered or Wood; all Types.

SEND FOR NEW 1961 STOCK LIST

FIRST MACHINERY CORP.

209-289 TENTH STREET, BROOKLYN 15, N. Y.

FMC Pays MORE For Your Surplus

PARKING ON THE PREMISES
Phone: STerling 8-4672
Cable Address: "EFFEMCY"

CIRCLE M ON READER SERVICE CARD

LIQUIDATION
ALCOHOL PLANT
OMAHA, NEBRASKA

BUY BEFORE REMOVAL

MAJOR ITEMS

5—Buflovak 42" x 120" dbl. drum dryers, ASME 160#
2—Bonnet 7' x 60' rotary dryers,
1—Bonnet 6' x 52' rotary dryer,
9—Davenport #1A #2A dewatering presses, vari-drives
2—French Oil type 2-S screw-type extraction presses 300 PSI, 60 HP.
2—Sweetland #12 pressure filters,
3—Lawrence 4" x 3" stainless centrif. pumps, 275 GPM @ 40'
6—Shriver 48" Cast Iron P. & F. filter presses, (50) chambers, hydraulic closure, closed deliv.
2—19,900 sq. ft. quadruple effect calandria type evaporators, copper tubes, cast iron bodies, with preheater & finishing pan.
5—24" stainless steel screw conveyors, up to 28' long
6—Ansonia 691 sq. ft. dbl. pipe coolers, copper tubes
3—American 654 sq. ft. spiral steel heat exchangers
1—1500 sq. ft. horiz. exchanger, (480)—¾" OD copper tubes, copper T. S. & shell, steel heads
18—Tubular heat exchangers, copper tubes: 1500, 1350, 1130, 637, 380, 290, 184, 176, 156 sq. ft.
1—Leader 96" x 44' high steel beer still, perf. trays
4—Leader Iron 96" dia. steel rectifying columns, 44' & 51' high, bubble cap trays
2—9500 gal. horiz. cookers, 9' dia. x 20' long, ½" shell & dished heads, agits.
10—Forster hammermills, #8 & #6, 100 & 75 HP.
1—Prater "Blue-Streak" pulverizer,
1—Fuller 12 x 20 pos. press. blower
2—Allis-Chalmers Inter-plane grinders, 100 HP
9—Davenport 5' x 25' inclined "slop" screens
2—Warren 12" x 12" cent. pumps
250—Steel centrifugal pumps, 1" to 12", 1 HP to 150 HP
2—Aldrich vert. triplex plunger piston-type pumps, steam drive
100—Steel & stainless steel screw conveyors, up to 161' long
5000 HP—TEFC motors, 3/60/220-440/, to 150 HP
20—Steam turbines, to 150 HP
200—Steel tanks & bins, all sizes
12—300 amp. portable welders, elec. & gasoline

SEND FOR CIRCULAR #960-A

PERRY EQUIPMENT CORP.

1413-21 N. Sixth St.
Philadelphia 22, Pa.
Phone POplar 3-3505

CIRCLE N ON READER SERVICE CARD

IN STOCK FOR 1961—

All Types of Chemical-Process Equipment!

PRICED RIGHT FOR IMMEDIATE DELIVERY!

SELECTED RECENT PURCHASES

1—Vulcan 60" dia. x 35 plate T316SS bubble-cap column.
1—Buflovak 32" x 52" dbl. drum dryer, ASME 100#.
1—Buflovak 6" x 8" lab. dbl. drum vacuum dryer.
1—American 42" x 120" dbl. drum dryer, ASME, S/S.
2—200 gal. T304SS reactors, jacketed, agit.
4—1350 gal. T347SS jkt. kettles, anchor agit.
1—3'-6" x 21' rotary dryer, 3/8" welded.
2—Komarek briquette presses, 150,000 PSI roll pressure.
1—Symons 2' standard cone crusher, 30 HP.
1—J. H. Day #8 Cinc. dbl. sigma mixer, 150 gal.
1—Stokes #RD-3 rotary tablet press.
2—Bird 24" x 38" horiz. centrifugal, T304SS.
1—Feinc 6' x 6' rotary vacuum filter, T304SS.
1—1800 gal. T316SS reactor, Jkt., Agit.
1—Patterson 6' x 10' pebble mill, Jkt., porcelain.
1—Louisville 4'-6" x 25' rotary steam-tube dryer.
6—Valley 36" Aluminum P. & F. filter presses.
1—Baker-Perkins #15-UUMM, 100 gal. dispersion-blade mixer, 100 HP, Jacketed, Compression Cover.

CENTRIFUGALS—FILTERS

1—Bird 18" x 28" contin. cent., T304SS.
3—Bird 24" x 24" contin., monel, type CH.
2—Bird 24" x 38" contin., conical, T304SS.
1—Bird 32" x 50" contin., horizl, T316SS.
20—Sharples #AS-16V super centrifugals, Inconel Const., vapor-tite, sludge disch. frame.
3—Sharples #C-20 Super-D-Hydrators, T316SS.
1—Tolhurst 48" susp. basket centrif., T304SS.
6—AT&M 40" susp. basket centrif., T304SS.
1—Bird 40" susp. basket centrif., steel.
1—Fletcher 40" susp. basket centrif., steel.
2—AT&M 32" susp. basket centrif., T304SS.
1—Tolhurst 26" susp. basket centrif., steel.
1—AT&M 12" susp. basket centrif., T304SS.
2—Oliver 5'-3" x 3' rot. vac. filters, T316SS, precoat.
1—Oliver 5'-3" x 8' rot. vac. filter, precoat, UNUSED.
1—Oliver 5'-3" x 8' rot. vac. filter, monel screens.
1—Niagara #510-28, 510 sq. ft. T316SS leaf filter.
2—Sweetland #12 steel filters.
6—Shriver 48" cast-iron P. & F. filter presses.

MILLS—PULVERIZERS

1—Raymond 66", 6-roller lo-side mill, 200 HP.
2—Raymond 50", 5-roller hi-side mills, dbl. whizzer or dbl. cone separator, oil journals.
1—Babcock & Wilcox #E-32 pulv., air-swept, 75 HP.
1—Dixie #5060 hammermill, 500 HP.
1—Mikro #3TH pulv., stirrup hammers.
2—Jeffrey type #B-2 hammermills, 24" x 20", 40 HP.
1—Kennedy 7' x 9' ball contin. mill, 150 HP.
2—Hardinge 7' x 36" conical pebble mills.
1—Allis-Chalmers 6' x 16' ball-tube mill.
3—Allis-Chalmers 5' x 22' ball-tube mills.
1—Allis-Chalmers 5' x 5' ball mill, 75 HP.
12—Abbe Eng. 6' x 8' pebble mills, 30 HP.
1—Allis-Chalmers 6' x 18' pebble-tube mill.
2—Patterson 8' x 10' pebble mills.
1—Symons 2' standard cone crusher, 30 HP.
1—Farrel 36" x 15" jaw crusher.
1—Buchanan 24" x 13" jaw crusher, 50 HP.
1—Mitchell 18" x 9" jaw crusher, 25 HP.

STAINLESS STEEL TANKS

1—5700 gal. horiz., T304SS, 6'-4" x 24', UNUSED.
2—4500 gal. horiz., T304SS, 8' x 12', UNUSED.
1—4300 gal. horizl, T304SS, 6' x 20', ASME 50#.
1—3700 gal. Vert., T304SS, 6' x 17', coils.
1—3400 gal. horiz., T316SS, 6' x 16', dished heads.
1—3300 gal. Vert., T304SS, 6' x 14', hemis. heads.
1—3000 gal. Vert., T304SS, 6' x 15', coils.
3—2750 gal. Vert., T316SS, 7' x 8', dished heads.
1—2500 gal. Vert., T316SS, 7' x 7', dished heads.
2—2300 gal. Vert., T316SS, 7' x 8', coils, agit.
4—2250 gal. Vert., T316SS, 7' x 6'-3", agit.
1—2100 gal. Vert., T316SS, 6' x 9'-10", cone bot.
1—1750 gal. Vert., T304SS, 5' x 12', coils.
12—1750 gal. Vert., T304SS hoppers, 235 cu. ft.
1—1600 gal. horiz., T304SS, 5' x 11', dished heads.
6—685 gal. Vert., T316SS, coils.
1—600 gal. Vertl, T304SS, 5' x 4', dished heads.

PERRY EQUIPMENT CORPORATION

1413-21 N. SIXTH ST. PHILADELPHIA 22, PA.

Phone POplar 3-3505

CIRCLE 0 ON READER SERVICE CARD

TRY IT BEFORE YOU BUY IT

GOOD USED MACHINERY ON APPROVAL

1—Buflovak forced Circulation SS Evaporator. 700 sq ft

2—Podbielniak type 316 SS Centrifuges. Mod 6080 & 9000

54—Stokes Model 212 C Vacuum Pumps. 115 CFM. 5 HP Motors

2—Dorrco 60' Double Rake Thickener mech. w/1½ HP Mtrs

3—Link-Belt Roto-Louvre Dryers 207-10, 310-16, & 705-24. Comp.

1—Struthers Wells 5' x 10' Single Roll Stain. Drum Dryer

1—Oliver 8' x 10' Rotary cont. Vac. Precoat Filter. Steel contact

3—500 gal. Steel jckid Kettles. 140 PSI. Arranged for Agit.

MACHINERY AND EQUIPMENT COMPANY
123 Townsend St. · San Francisco 7, California

CIRCLE P ON READER SERVICE CARD

USED EQUIPMENT FOR SALE

Permutit Water Softener, 33,000 gallons per regeneration, fair condition $500
Union Air-Driven Simplex Pump, 2 GPM at 5,000 psig discharge pressure, good condition $500
Union Triplex Slurry or Liquid Pump, 50 GPM at 1,000 psig with 30 HP, 440 V Adjustospeed motor, good condition $2500
Willey 1½" Slurry Pump, 75 GPM at 40 foot head, good condition $250
Allis-Chalmers Single Stage Centrifugal Pump, with 5 HP motor, 75 GPM at 60 foot head, good condition $250
Denver 7' x 2' Super Agitator, with 7½ HP motor, good condition $800
Fuller #3 Roll Feeder with 2 HP Varispeed motor, excellent condition $800

For Information, Contact

GOUVERNEUR TALC. CO., Inc.
Gouverneur, New York

CIRCLE X ON READER SERVICE CARD

5' Dia. 6' Face 316 SS Feine Vac. Filter, Complete
2—48" Sweco Vibrating Screens Model A-1D-8
De Laval AC-VO Nozzeimatic Separator, Complete
De Laval 304 SS P-12-IF Plate Heat Exchanger
Niagara Hygro Air Drying System, 13,000 CFM 30 Degree Dew Point, Complete

Tel: HEnderson 2-1200
Jersey City, N. J.

CIRCLE Y ON READER SERVICE CARD

MODERN REBUILT MACHINERY

UNION Rebuilt Machinery Established 1912

Baker Perkins, Day, W. & P. Heavy Duty Mixers, 5 to 150 gal. caps., Jacketed and Unjacketed.
J. H. Day and Baily Dry Powder Mixers, 25 lb. to 2000 lb. capacities.
Stokes 90-D Automatic Stainless Steel Tube Filler and Closer.
Pneumatic Scale High Speed Automatic Cartoning Line with Feeder, Bottom Sealer, Top Sealer, Wax Liner, Interconnecting conveyors.
Standard Knapp, A-B-C, Ferguson and Ceco Case Sealers.
WRAPPERS: Package Machinery, Hayssen, Hudson Sharp, Battle Creek, Scandia, Wrap-King, all sizes and models.
Coating Pans—all sizes, including 24", 36", 38" and 42".
Colton 6 ft. diameter Stainless Steel Pan.
Stokes & Smith Models G1, G2, HG84, HG87 and HG88 Auger Powder Fillers.
Raymond "O" Pulverizer.
Mikro Pulverizers, Bantam, 1SH, 2TH, 3TH and 4TH.
Fitzpatrick Stainless Steel Comminuters.

Complete Details and Quotations Available on Request

UNION STANDARD EQUIPMENT CO.

318-322 Lafayette St. New York 12, N. Y. CAnal 6-5333
167 No. May St. Chicago 7, Illinois SEely 3-7845

CIRCLE Q ON READER SERVICE CARD

COMPRESSORS

No better values at any price

110 CFM 3000 PSI Ing. GC 50BW
138 CFM 100 PSI 7x7, Ing. ES, CP & Jay
288 CFM 100 PSI 9x9 Ing. Worth, CP
311 CFM 1500 PSI 10½-7⅞-3¾x13 IR-ES3
351 CFM 350 PSI 11-5x11 CP TCB-2
364 CFM 100 PSI 10x9 Jay WG 9
465 CFM 100 PSI 12x11-IR-ES CP.T. Worth HB
502 CFM 125 PSI 12x13 Worth HB
686 CFM 100 PSI 14x13 Ing. ES
800 CFM 100 PSI 14½-9x7 Ing. XLE
877 CFM 125 PSI 17-10½x14 IR, XRB
1050 CFM 60 PSI 13-13x12 IR-XRE
1055 CFM 110 PSI 18-11x12 CP-OCE
1351 CFM 125 PSI 18½-11½x8½ Worth Y
1545 CFM 110 PSI 21-13x14 Ing. XRE
1665 CFM (actual) 100 PSI C300-300H Fuller
2520 CFM 125 PSI 17-10¾x8 Clark CMA-4L

AMERICAN AIR COMPRESSOR CORP.
Chem. Road, North Bergen, N.J. UNion 5-1397

CIRCLE S ON READER SERVICE CARD

2 colloid Mills 40 HP EX. PR.
Dowtherm 225 KW
Stokes R Tablet
50 gal. S.S. Autoclave 2000 lbs. pressure
3½ gal. S.S. Autoclave 2000 lbs. pressure
Vulcanizer 60" x 9' 125 lbs.
Sweetland #2 all stainless
Stainless steel Ball Mill
Proctor & Schwartz finned drum driers

MACHINECRAFT CORPORATION
800 Wilson Ave. (East of Doremus)
Newark 5, N. J. MI 2-7634

CIRCLE T ON READER SERVICE CARD

Searchlight Equipment Locating Service

NO CHARGE OR OBLIGATION

This service is aimed at helping you, the reader of "SEARCHLIGHT", to locate Surplus new and used equipment not currently advertised. (This service is for USER-BUYERS only.)

How to use: Check the dealer ads to see if what you want is not currently advertised. If not, send us the specifications of the equipment wanted on the coupon below, or on your own company letterhead to:

Searchlight Equipment Locating Service
Classified Advertising Division
Chemical Engineering
P.O. Box 12, N.Y. 36, N.Y.

Your requirements will be brought promptly to the attention of the equipment dealers advertising in this section. You will receive replies directly from them.

Searchlight Equipment Locating Service
Classified Advertising Division
CHEMICAL ENGINEERING
P.O. Box 12, N. Y. 36, N. Y.

Please help us locate the following:

.....
.....
.....

Name .....
Title .....
Company .....
Street .....
City ..... Zone ....
State 1/9/61

4 CHEMICAL PLANT LIQUIDATIONS

NIAGARA FALLS, N. Y.
EVERETT, MASS.
BALTIMORE, MD.
JERSEY CITY, N. J.

Catalogs Available. Write for Your Copy

HEAT & POWER CO. INC.
60 E. 42nd St., N. Y. 17 MU 7-5280

CIRCLE R ON READER SERVICE CARD

ECH SPECIAL

Abbe Eng. Jacketed 5' x 6' Ball Mill, chrome manganese steel. Price $2750.00.

EQUIPMENT CLEARING HOUSE, INC.
111 33 Street Brooklyn 32, N. Y.
90uth 8-4451—4452—8782

CIRCLE U ON READER SERVICE CARD

IMMEDIATE DELIVERY

CENTRIFUGE: Sharples Super Decanter, S/S Model PN 14.
FILTER: Niagara Style 8 horizontal type; Sparkler Models 14-4; 33 D-7; 3326 R.
MILLS: Rotary cutters; J. B. Sedberry 4 WDC; Gruendler No. 1 Supermaster; Mikro 2 TH; Prater Blue Streak
MIXERS: Baker Perkins 300 Gal. with hydraulic tilt and self contained with hydraulic pump; 4,000# Grede & Gray horizontal ribbon blender; Hobart Mixanette, laboratory size; J. P. Devine 300 gal. jacketed for 100 psi.
PRESSES: 150 ton Stokes Hydraulic & Toggle presses; Colton 3 RP and 4½ T; Bolling hydraulic press.

AARON EQUIPMENT CO
9370 Byron Street
Schiller Park, Illinois
Gladstone 1-1500

CIRCLE V ON READER SERVICE CARD

Hold Tight to Value

Buy GELB

CHEMICAL PROCESS EQUIPMENT

1—Hersey stainless steel rotary dryer, 3' x 20'
3—Theo. Walters 300 gal. Hastelloy B jacketed reactors
1—Pfaudler Series EL 750 gal. glass lined jacketed reactor, 90# working pressure jacket, complete with impeller type agitator, baffle and drive
1—Pfaudler Series R 300 gal. glass lined jacketed reactor, complete with impeller type agitator, baffle and drive

AUTOCLAVES, KETTLES AND REACTORS

2—Blaw-Knox 600 gal. steel reactors, complete with double motion agitators and drives, 50# jacket, 50# internal
1—Steel 1200 gal. vertical pressure tank, 150 psi
1—Oat type 316 SS 10 gal. jacketed autoclave, 150 psi jacket and internal, complete with agitator and drive
2—Monel 2500 gal. jacketed autoclaves, 175# jacket and internal pressure
1—Van Alst 300 gal. stainless steel jacketed kettle
1—Blaw Knox 300 gal. stainless steel vacuum reactor
1—Blaw-Knox 250 gal. stainless steel jacketed vacuum reactor
1—Van Alst 250 gal. stainless steel jacketed kettle, complete with stainless steel column and condenser
1—Patterson 40 gal. jacketed reactor, complete with agitator and drive, 50# jacketed and 50# internal
1—Alloy Fabricators type 316 stainless steel 2600 gal. vacuum receiver
1—Pfaudler 30 gal. Series P, jacketed reactor, complete with impeller type agitator, baffle and drive
2—Pfaudler Series EM 300 gal. glass lined jacketed reactors, complete with anchor type agitator and drive

DRYERS

2—Bonnet rotary kilns, 8' x 115', complete
1—Bonnet rotary cooler, 8' x 50', complete
1—American 42" x 120" double drum dryer, ASME, N. B. constructed, complete with drives and motors
1—Allis Chalmers stainless steel 6' x 50', rotary dryer, complete
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
3—Link Belt steel roto louver dryers, Model 207-10, 310-16, 604-20
1—Buflovak stainless steel jacketed rotary vacuum dryer, 3' x 15'
1—Proctor & Schwartz stainless steel apron dryer, 2' x 20'
3—Buflovak steel jacketed rotary dryers, 3' x 15', 5' x 20', 5' x 35'
1—Stokes Model 59DS steel rotary vacuum dryer, 5' x 30'
1—Western Precipitation Corp. stainless steel pilot plant spray dryer, Type N-2
1—Bowen stainless steel pilot plant spray dryer
2—Buflovak stainless steel rotary vacuum dryers, 5' x 30'
1—Stokes single door vacuum shelf dryers with 6 shelves, 24" x 36"

FILTERS

3—Dorrco rubber covered filters, 6' x 2'
12—Sweetland #12 filters with 72 stainless steel leaves
1—Niagara stainless steel filter, Model 510-28
1—Oliver horizontal filter, 3'
1—GATX stainless steel pilot plant filter, 2' x 6'
1—Oliver stainless steel rotary vacuum pressure precoat filter, 5'3" x 8'
1—Oliver stainless steel rotary vacuum filter, 3' x 4'
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers
10—Shriver plate and frame filter presses, 12" to 42"

CENTRIFUGES

1—AT&M 48" stainless steel, suspended type centrifuge, complete with plow, motor and imperforate basket

THE GELB GIRL—JANUARY 1961

1—Fletcher 48" stainless steel, underdriven centrifuge, complete with perforate basket and motor
1—AT&M 40" stainless steel, suspended type centrifuge, complete with perforate basket, plow and motor
7—Western States 40", type 316 stainless steel, suspended type centrifuges, complete with perforate baskets, plows and 40 HP motors
2—Fletcher 40" rubber covered, underdriven centrifuges with perforate baskets and motors
1—AT&M 26" type 316 stainless steel, suspended type centrifuge, complete with perforate basket, plow and motor
4—Tolhurst 40" center slung, rubber covered centrifuges, complete with perforate baskets and motors
1—Tolhurst 30" center slung, rubber covered centrifuge, with perforate basket and motor

MIXERS

1—J. H. Day stainless steel double arm sigma blade vacuum jacketed mixer, 5 gal.
1—Baker Perkins stainless steel double arm sigma blade mixer, 9 gal. working capacity
1—Robinson stainless steel 125 cu. ft. horizontal double ribbon blender
2—Sturtevant #7 dustite rotary batch blenders, NEW
15—Robinson type 304 stainless steel horizontal blenders, 255 cu. ft.
1—Baker Perkins Size 16, Type UUEM, 150 gal. jacketed doublearm dispersion type mixer, complete with compression cover and 100 HP motor
1—Stokes stainless steel granulating mixer, Model 21-J

MISCELLANEOUS

1—Stewart Bolling 2 roll chrome plated plastic mill, 8" x 16"
1—Raymond 2 roll high side roller mill
1—Ross 6" x 14" 3 roll paint mill, complete
1—Vulcan stainless steel bubble cap column, 4' x 25 Plates
1—Badger type 316 stainless steel bubble cap column, 42" dia. with 11 trays
1—Badger type 316 stainless steel bubble cap column, 36" dia. with 8 trays
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 and 600 sq. ft.
1—Downington type 316 SS heat exchanger, 750 sq. ft.
1—Griscom Russell stainless steel heat exchanger, 900 sq ft.
4—Patterson type 316 SS condensers, 200 and 300 sq. ft.
4—Davis Engineering Carpenter 20 heat exchangers, 125 sq. ft., NEW
20—Davis Engineering stainless steel heat exchangers, 102, 119, 136 and 166 sq. ft., NEW
2—Swenson type 316 SS vacuum crystallizers, 3'6" x 12' and 2' x 12'
1—Mikro #1SH pulverizer, complete
3—Williams type 316 SS hammermills, Model AK

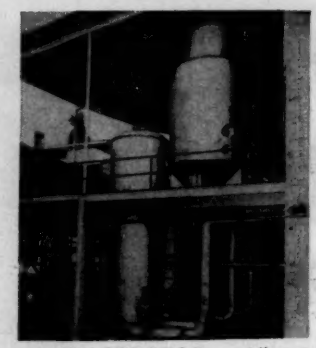
2—Mikro##TH stainless steel pulverizers, complete with 40 HP motor.
1—Struthers Wells type 316 SS jacketed reactor 2000 gal., complete with agitator and drive
1—Stokes stainless steel jacketed rotary vacuum dryer, 3' x 15'
1—Stokes stainless steel jacketed rotary vacuum dryer, 2' x 6'

R. GELB & SONS, INC.
U. S. HIGHWAY 22, UNION, N. J. · MURDOCK 6-4900
75 ANNIVERSARY

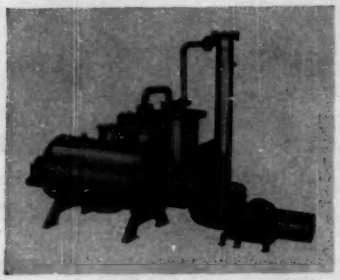
CIRCLE W ON READER SERVICE CARD

G-B

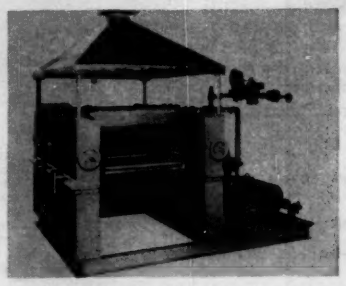
HEAT TRANSFER EQUIPMENT



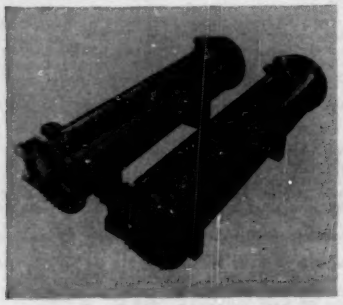
▲ EVAPORATOR — All stainless steel quadruple effect.



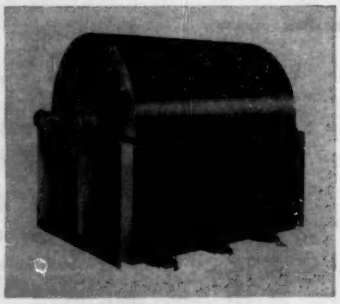
▲ VACUUM ROTARY DRYER — Designed for efficient removal of moisture at low temperatures.



▲ DRUM DRYERS—Available with a variety of feed arrangements.



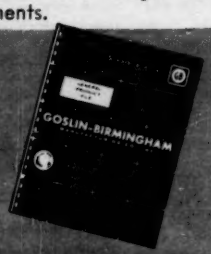
▲ HEAT EXCHANGERS — Special design with high alloy and multipass liquor flow.



▲ FLAKERS—Rapid and continuous operation. Diameter sizes from 18" to 60". Lengths to suit requirements.

Goslin-Birmingham process equipment is custom designed to meet your specific requirements.

Write for more detailed information



GB

GOSLIN-BIRMINGHAM

MANUFACTURING CO., INC.

P.O. BOX 621 • BIRMINGHAM, ALABAMA

FILTERS • EVAPORATORS • DRYERS • FLAKERS

CONTRACT MANUFACTURING including HEAVY CASTINGS

Index of Advertisers

Abbé Engineering Co. 156
Aerotec Industries, Inc. 158
Allied Chemical Corp.
General Chemical Div.
(Baker & Adamson) 39
Allis-Chalmers 145, 147
American Chain & Cable Co.
R & PC Valve Div. 72
Anderson Co., V. D. 136, 186
Armstrong Machine Works 177
Astropower, Inc., Subsidiary of
Douglas Aircraft Company 49
Autonetics, Division of
North American Aviation, Inc. 127
Avondale Shipyards, Inc. 10-11

Bailey Meter Co. 179
Bethlehem Foundry & Machine Co. 188
Bird Machine Co. 2
Bishop & Co. Platinum Works, J. ... 4

Chemical & Power Products, Inc. ... 168
Chicago Bridge & Iron Co. 69
Clark Bros., One of the Dresser Industries 18-19
Cleaver Brooks Co. 70
Continental-Emsco Company, a Division of Youngstown Sheet and Tube Company ..... Third Cover
Cooper-Bessemer 22-23
Coppus Engineering Corp. 53
Crane Co. 119
Crane Packing Co. 138

Darnell Corp. 184
Davenport Machine & Foundry Co. 187
Dawson Engineering Co., F. C. 183
Denver Equipment Co. 139
Dixon Corp. 181
Dodge Manufacturing Co. 164, 165
Dorr-Oliver Incorporated 36-37
Douglas Aircraft Co.
Astropower, Inc. Subsidiary 49
Dow Corning Corp. 59
Durabla Manufacturing Co. 148
Duraloy Co. 159
Duriron Company, Inc., The 125
du Verre, Inc. 178

Eimco Corporation ..... Second Cover
Electronic Associates, Inc. 80
Enjay Chemical Co., Div. of
Humble Oil & Refining Co. 57
Ever-Tite Coupling Co. 41

Falls Industries, Inc. 81
Fischbein Co., Dave 182
Fischer & Porter Co. 201
Fisher Governor Co. 133
Flo-tronics, Inc. 162
Fluid Energy Processing & Equipment Co. 141
Foxboro Co. 12-13
Fuller Company, Inc. 55

Gabb Special Products, Inc. 172
General Electric Co. (Apparatus) . 175
Goodrich Industrial Products Co.
B. F. 1
Goslin-Birmingham Mfg. Co. 198
Graver Tank & Mfg. Co. 51
Great Lakes Carbon Co.
Electrode Division 47
Grinnell Co. 143
Gustin-Bacon Mfg. Co. 134, 135

Hardinge Co. 140
Harshaw Chemical Co. 167
Haynes Stellite Co.
Div. of Union Carbide Corp. 131
Hercules Filter Corp. 200
Hercules Powder Co. 16-17
Hooker Chemical Corp. 71
Hough Co., Frank G. 31

Illinois Water Treatment Co..... 184

Jamesbury Corporation 45
Johnston Pump Co., Div. of Youngstown Sheet and Tube Co. 137

Kellogg Co., M. W..... 151
Kennedy Van Saun Mfg. & Engrg. Corp. 123

LaBour Company 30
Link-Belt Co. 14-15
Lukens Steel Co..... 67

Magnetrol, Inc. 182
Manzel Division of Houdaille Industries, Inc..... 199
Marsh Instrument Co., Div. of Colorado Gas & Oil Corp..... 188
McGraw-Hill Book Co..... 173
Mine & Smelter Supply Co..... 146
Minneapolis-Honeywell 8-9, 181
Mitts & Merrill..... 186
Morehouse-Cowles Co. 34
Murray Mfg. Co., D. J..... 142

Nalco Chemical Co..... 176
Nash Engineering Co..... 78
Nicholson & Co., W. H..... 161
Newark Wire Cloth Co..... 160
Norton Company 29

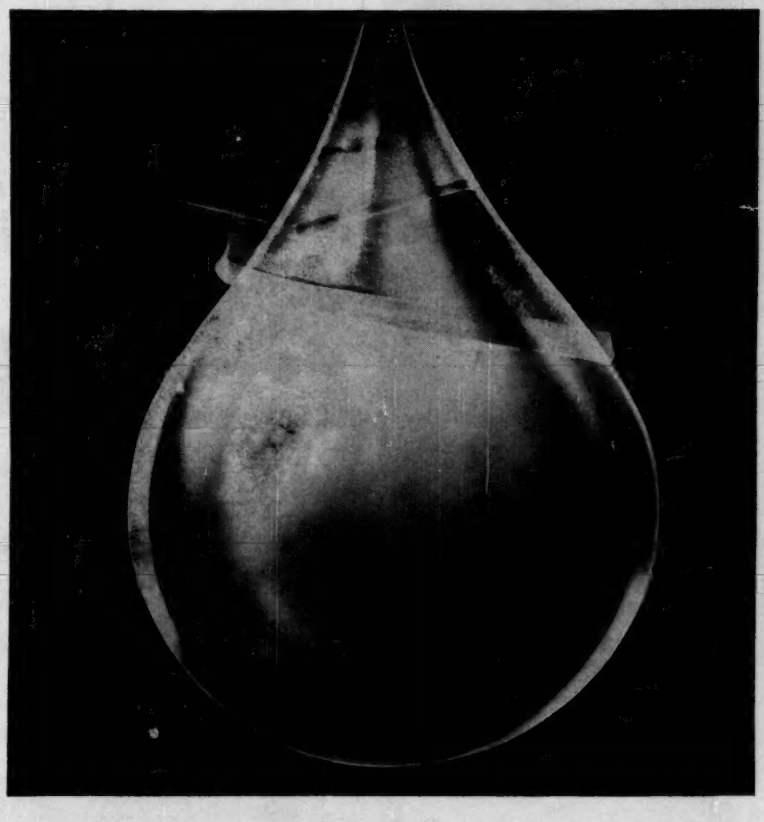
Orbit Valve Co..... 65

Pennsalt Chemicals Corp..... 79
Pfaudler Div. of Pfaudler Permutit, Inc. .....26-27, Fourth Cover
Pfizer & Co., Inc., Chas.....6-7
Pittsburgh Lectrodryer Div. McGraw-Edison Co. 189
Platecoil Division Tranter Manufacturing, Inc..... 28
Protectoseal Co. 185

Advertising Sales Representatives

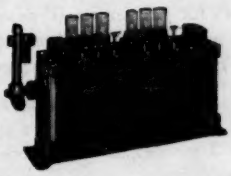
Atlanta 9.....R. K. Burnet
1375 Peachtree St. N.E., TRinity 5-0523
Boston 16.....A. S. Reed
McGraw-Hill Bldg., Copley Square, COngress 2-1160
Chicago 11.... Gene Davis, J. M. Rodger, Jr.
520 N. Michigan Ave. MOhawk 4-5800
Cleveland 13.....John G. Mitchell
55 Public Square SUperior 1-7000
Dallas 1.....Robert T. Wood
Vaughn Bldg., 1712 Commerce Riverside 7-9721
Denver 2.....John Patten
1700 Broadway ALpine 5-2981
Detroit 26.....Chas. M. Crowe, Jr.
856 Penobscot Bldg. WOodward 2-1793
Frankfurt/Main .....Stan Kimes
85 Westendstrasse
Geneva .....Michael R. Zeynel
2 Place du Port
Houston 25.....Gene Holland, John Grant
W-724 Prudential Bldg. JAckson 6-1281
London EC4..E. E. Schirmer, Edwin E. Murphy
95 Farringdon St.
Los Angeles 17.....John B. Uphoff
1125 W. Sixth St. HUntley 2-5450
New York 36—R. G. Frederick, A. L. Gregory, John R. Emery
500 Fifth Ave. OXford 5-5959
Philadelphia 3.....E. M. Schellenger
6 Penn Center Plaza LOcust 8-4330
Pittsburgh 22.....G. S. Ryan
4 Gateway Center EXpress 1-1314
Portland 4.....Scott B. Hubbard
Room 445, Pacific Bldg. CApitol 3-5118
St. Louis 8.....J. M. Rodger, Jr.
3615 Olive Street JEfferson 5-4867
San Francisco 4.....R. T. Koch
68 Post St. DOuglas 2-4600

HOW TO educate



a drop of oil...

Just put it through a Manzel force-feed lubricator and any oil drop knows where it's going and how to get there fast. Manzel lubricators deliver just the right amount of oil to bearings, cylinders and packings. They start, stop, speed up and slow down in perfect synchronization with your machinery...unaffected by high steam, gas or air pressure. Whatever your field, there's a Manzel lubricator to meet your needs. For our catalog, write Manzel, 250 Babcock Street, Buffalo 10, New York. Whatever your lubricating problem, you get the right answer if you



ask the man from

A UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

Resistoflex Corp. 61
Robertshaw-Fulton Controls Co.
Fulton Sylphon Div..... 149
Rockwell Co., W. S..... 200

Shriver & Co., T..... 166
Sier Bath Gear & Pump Co..... 163
Sly Mfg. Co., W. W..... 174
Sprout, Waldron & Co..... 150
Stokes Corp., F. J..... 153
Sturtevant Mill Co..... 180
Sulzer Bros., Inc..... 183

Taylor Instrument Companies....24-25
Thermal American Fused Quartz
Co. 185
Thermo Electric Co..... 154
Timken Roller Bearing Co..... 63

Union Carbide Chemicals Co.
Div. of Union Carbide Corp..... 129
U. S. Steel Corp.
Stainless (Alloy) 20-21
U. S. Stoneware Co..... 32

Valcor Engineering Co..... 180
Viking Pump Co..... 152
Vogt Machine Co., Henry..... 82

Weinman Pump Mfg. Co..... 144
Western Precipitation Div. of Joy
Manufacturing Co. 73
Western States Machine Co..... 157
Williams Patent Crusher & Pulverizer Co. 155
Wisconsin Protective Coating Co... 190
Wyssmont Co. 202

Zero-Max Co. 187

PROFESSIONAL SERVICES 190

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

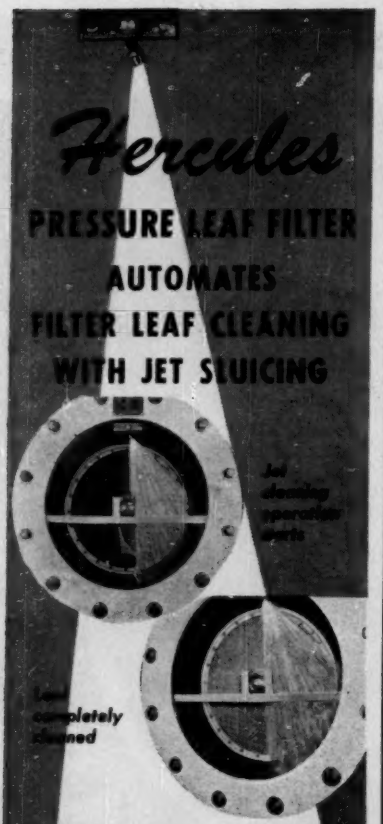
EMPLOYMENT
OPPORTUNITIES 191, 192

BUSINESS OPPORTUNITIES..... 192

EQUIPMENT
(Used or Surplus New)
For Sale 192-197
WANTED
Equipment 192

ADVERTISERS INDEX

Aaron Equipment Co., Div. of Areco Inc.. 196
American Air Compressor Corp..... 196
Brill Equipment Co..... 193
Chemical & Process Machinery Corp..... 191
The Chemstrand Corp..... 192
Equipment Clearing House..... 196
First Machinery Corp..... 194
Gelb & Sons Inc., R..... 197
General Electric Co..... 191
Gouverneur Talc Company Inc..... 196
Heat & Power Co., Inc..... 196
Little Inc., Arthur D..... 197
Lawler Co. 193
Loeb Equipment Supply Co..... 193
Machinecraft Corp. 196
Machinery & Equipment Co.....193, 196
Monarch Personnel 191
Machinery & Equipment Co., Used Div.
Haring Equipment Corp..... 192
Perry Equipment Corp.....194, 195
Shockley Transistor 191
Stanhope Inc., R. C..... 192
Stein Equipment Co..... 193
Secheurs Atomiseurs Co..... 192
Union Standard Equipment Co..... 196



With Hercules "Roto-Jet" filters leaves are internally cleaned automatically.

Internal jet cleaning is accomplished by powerful jets issuing from nozzles on a header at top of tank shell. These nozzles, centered between adjacent leaves, clean facing surfaces of each pair of leaves. The operator merely flips a switch and the entire cleaning operation is taken over by a cam timer. As leaves turn inside filter at 2 to 4 RPM the jets sluice off spent filter cake which washes out of filter through the drain. Then leaf rotating drive stops automatically, jet header and drain valves close, and filter is ready for precoating. (If desired precoating, and entire filter operation can be completely automated.)

The cleaning operation requires only 6 to 8 gpm per jet, over a period of 2 to 3 minutes, at a pressure of from 45 to 60 psig.

For full details of Hercules jet cleaned "Roto-Jet" Filters write for a copy of our 16 page illustrated catalog.

HERCULES FILTER CORP.
208 ETHYL AVENUE
HAWTHORNE, NEW JERSEY

SAVE
with
ROCKWELL
RESILIENT SEATED
BUTTERFLY
VALVES

SAVE SPACE

Valve face-to-face is a fraction of the face-to-face of a gate valve. We call it a "wafer" valve.

SAVE WEIGHT

From 60 to 80 percent, depending on size.

SAVE COST

In initial outlay and in overall maintenance

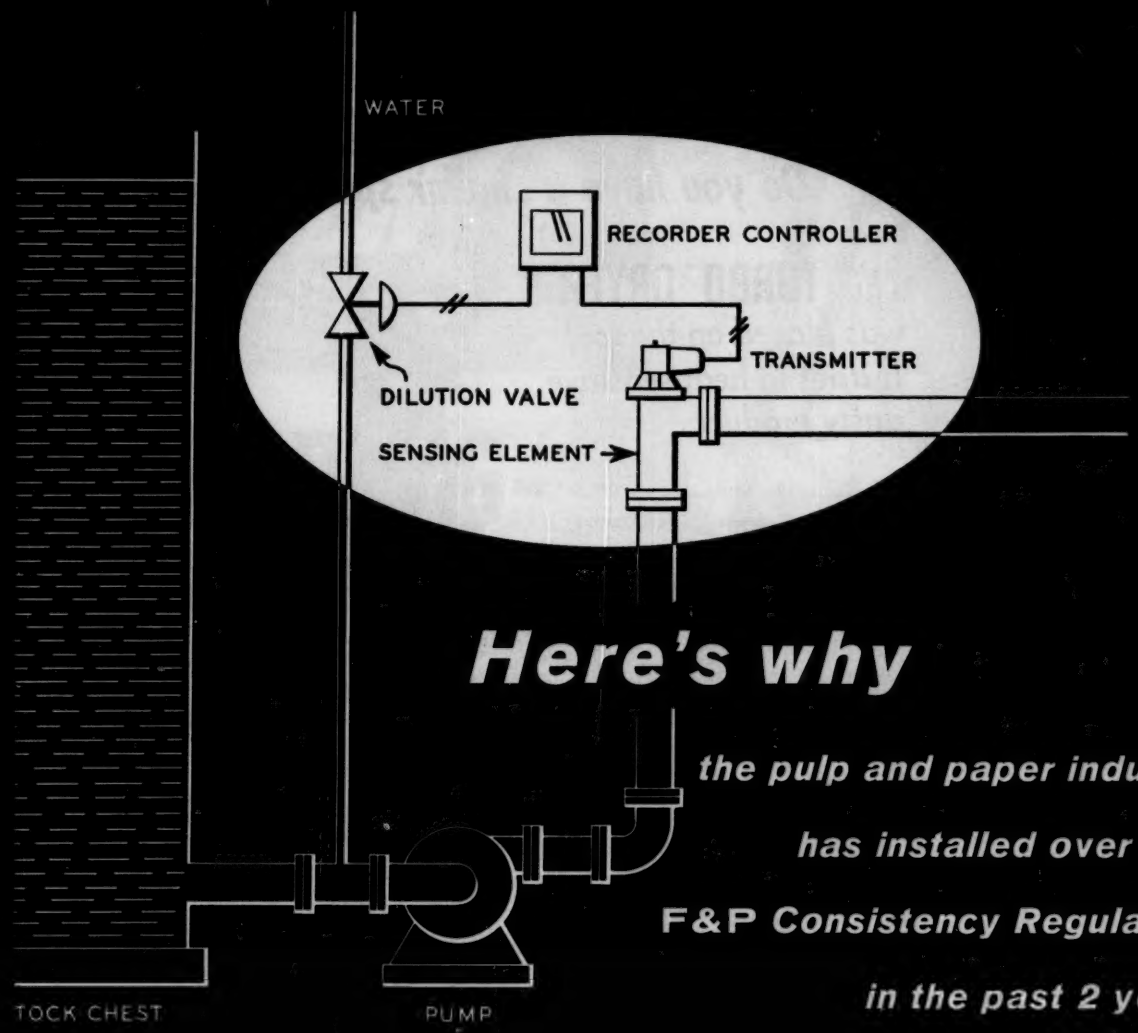
SAVE TROUBLE

Valve disc shuts off leak-tight against resilient seat from maximum line pressure to high vacuum. The disc cannot jam. Valve is self-cleaning. "Keelok" snap-in type liner is renewable. Control may be manual or automatic.

Write for Bulletin 590X

W. S. ROCKWELL COMPANY
2300 Eliot St. • Fairfield, Conn.

Made and sold in Europe by
COCKBURNS, Ltd. Glasgow S.W.2, Scotland



Here's why

the pulp and paper industry has installed over 600 F&P Consistency Regulators in the past 2 years

■ **Performance**—Has in-line sensing element . . . regulates to any consistency, from 2% to 8% without part changes . . . has high speed of response . . . accurate to better than 0.1% consistency . . . variable sensitivity . . . immune to changes in freeness and velocity. Another unit covers consistencies from 0.8% to 2.5%.

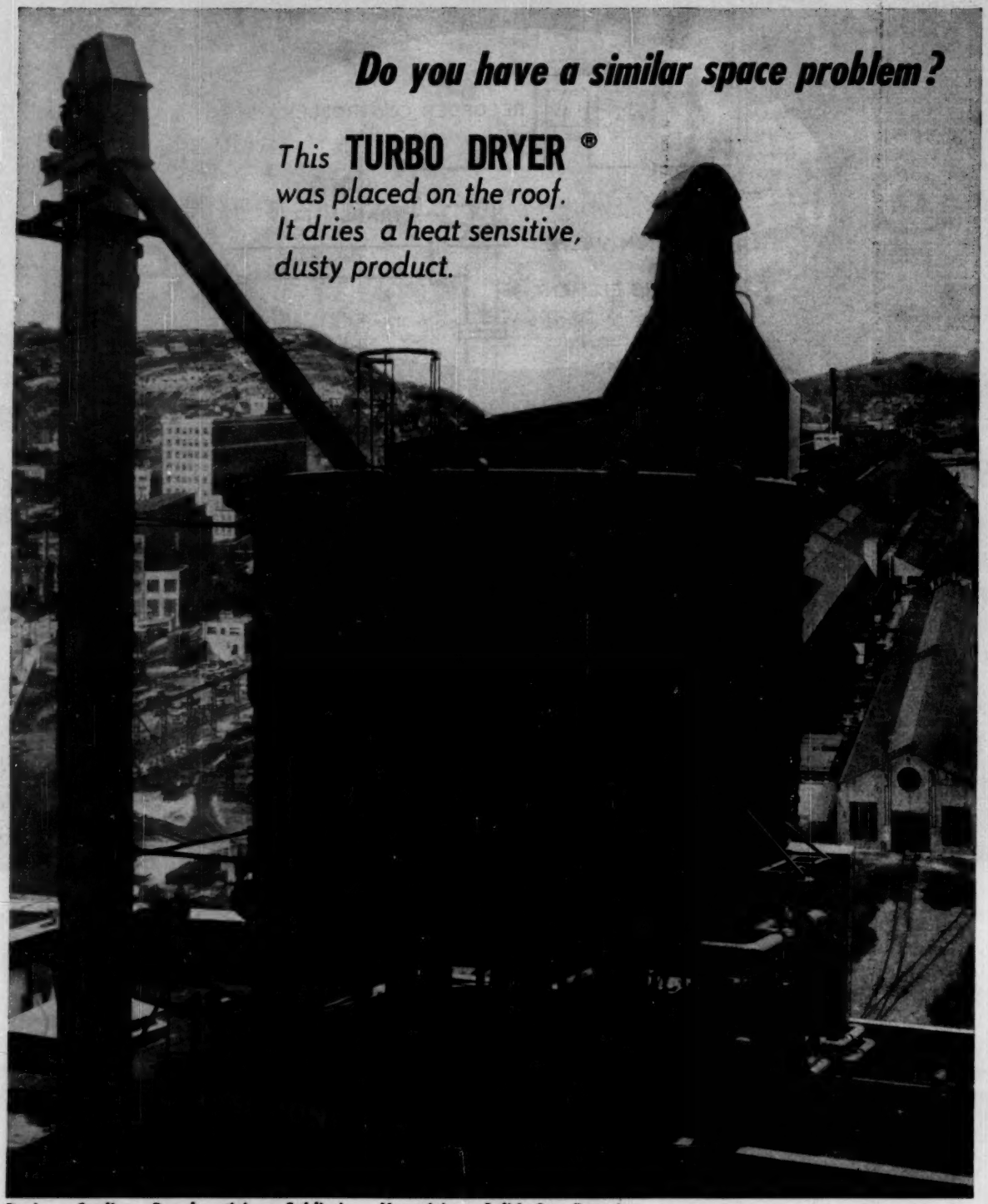
■ **Maintenance**—Minimum maintenance required . . . light weight (transmitter 40 lbs.) . . . easy to assemble . . . no seals or water purges . . . no electric drives . . . no critical bearings. Start-up assistance by factory trained specialists.

■ **Installation**—Low installation cost . . . no extra supports . . . minimum head room required above transmitter . . . small . . . light weight . . . easy to handle.

■ **Plus**—One manufacturer for all components (sensing element, transmitter, recorder, controller) . . . 4-week delivery on all sizes, from 6″ to 30″ pipe . . . economical price includes start-up assistance by qualified field service engineers.

Complete specifications on the Consistency Regulator are available from your local F&P field engineer, supported by pulp and paper industry managers and system engineers at Fischer & Porter Co., 111 County Line Road, Warminster, Pa. In Canada, write Fischer & Porter (Canada) Ltd., 2700 Jane Street, Toronto.

FP FISCHER & PORTER COMPANY *COMPLETE PROCESS INSTRUMENTATION*



Drying, Cooling, Desolventizing, Subliming, Vaporizing, Solid Gas Reacting.

TURBO DRYER

16 mm sound and color film is available on loan to institutional engineering groups.

Unique drying test facilities available.

IN GREAT BRITAIN : STURTEVANT ENGINEERING CO., LTD., LONDON EC 4

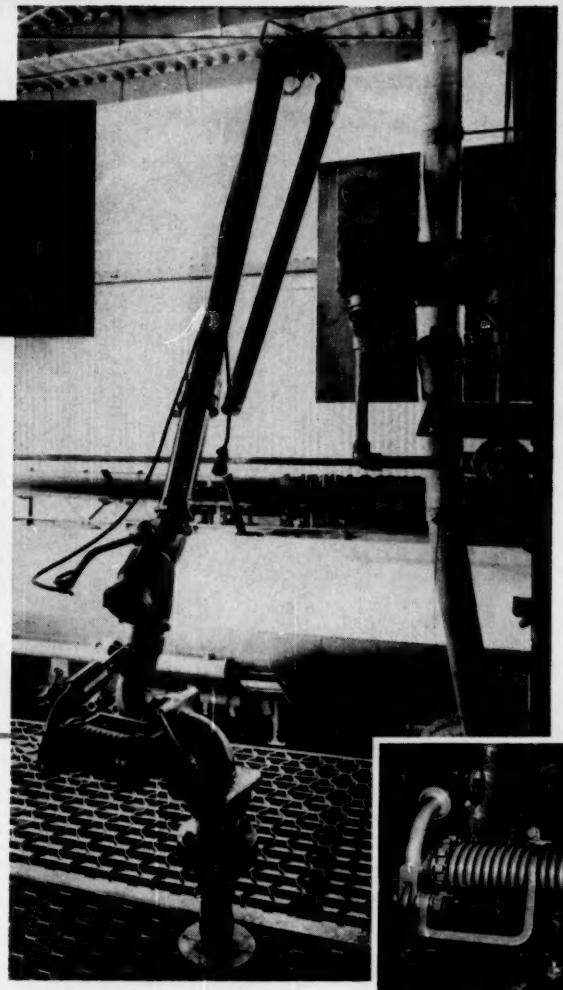
WYSSMONT
COMPANY, INC.
Drying & Process Engineers
27-10 Bridge Plaza South
Long Island City 1, N. Y.

Representatives in principal cities.

NEW

SPRING-BALANCED LOADING ARM

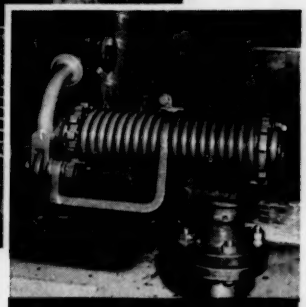
. . for faster, safer loading of petroleum and chemical products



You can see how Continental-Emsco's use of a torsion-type spring makes this loading arm compact and streamlined. Weights, pulleys, cables are eliminated, so platforms are cleaner . . more modern looking . . safer for personnel.

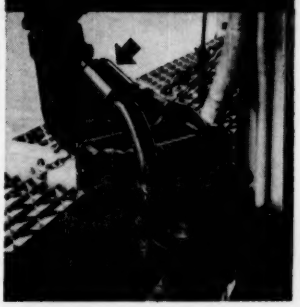
These thoroughly field proven, extremely rugged units incorporate heavy-duty bearings which are widely spaced to withstand continual loading and sudden, severe shocks. Riser joints are made of steel to take the punishment of the hardest loading operations. Packing can be replaced without removing joint from the arm or disturbing bearings, and Buna "N", Teflon or Viton "A" packing is available for handling a wide variety of products . . assuring the lowest possible cost.

Standard models are available in 3" or 4" sizes in either rigid or telescoping designs with flanged or threaded riser connections. Six standard models provide the variety of designs necessary to replace old arms or to equip new platforms at minimum cost. Custom-designed arms can be furnished to fit any special installation. Modernize your platform with competitively priced Continental-Emsco spring-balanced loading arms.



DOUBLE SPRING ASSEMBLIES

EXCLUSIVE SNUBBER SPRING



Write, wire or call today for complete information.

CONTINENTAL-EMSCO COMPANY
a Division of The Youngstown Sheet and Tube Company

SJ006

Industrial Products Division • P. O. Box 359 • Dallas 21, Texas

How to store "problem products" at a profit

If you handle any of these products, you might want to investigate the savings possible through Pfaudler® Glasteel storage tanks.

1. If your product is sticky, Glasteel (glass inside, steel outside for strength) makes cleaning easy. The inside surface is *hard* and *smooth,* so there's little chance for your product to adhere and build up.

2. If your product is corrosive, Glasteel ends the constant maintenance and replacement you encounter with ordinary materials. You can store all acids (except hydrofluoric) and most alkalies at ambient temperatures *without* fear of corrosion.

3. If your product is ultra-sensitive, Glasteel protects it from contamination. Because glass is essentially *inert,* it will not react in any way with what you put in contact with it. That's one good reason why Glasteel storage is a standard practice in the pharmaceutical industry.

4. Two ways to save. If you need tanks of 10,000 gallons or larger, your savings are immediate because Glasteel costs less than stainless. (For example, in the 30,000 gallon range they cost half as much as stainless.)

In tanks of any size for corrosive storage, you save over the years because Glasteel gives you long service life (up to 20 years or more) with very little maintenance.

You can get Glasteel storage tanks in horizontal or vertical models with capacities from 500 to 35,000 gallons. Openings and nozzle arrangements are available to fit your specific needs.

Facts for your files. Our Bulletin 975 spells out how and why you save with Glasteel storage and gives complete specifications. For your copy, write to our Pfaudler Division, Dept. CEB-11, Rochester 3, N. Y.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS...the science of fluid processes

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.